BIOLOGICAL PROBLEMS AND THE AMERICAN ASSOCIATION OF ANATOMISTS

HENRY H. DONALDSON

Address of the President at the meeting of the American Association of Anatomists, December 27, 1916

The purpose of this address is to discuss the relations of anatomy—as represented by our Association—to the problems of biology, and to consider our future course in the light of our past record.

My opportunity to deal with these matters has come as a result of your kindness in placing me in the presidential chair. I wish to express my appreciation of this honor which you have conferred, and also to venture the hope that this address may serve to indicate my interest in our common development.

Let me begin with a few words on the historic relations of anatomy.

It is easy to see that the divisions of biology have been named in a rather incongruous way. For example: Zoology is defined by its material; animals. Physiology, by a great domain; nature. Pathology, by a state; disease, and Anatomy, by a mode of procedure; dissection.

Strictly speaking therefore the anatomist is one who cuts up things—with the common connotation that his dissection is applied to the adult human body. But, as these instances show, derivations are hardly illuminating.

As we know, all workers in science are arbitrarily labelled, for as they enter the hall of science they find at the very threshhold a robing room. Here hang the gowns mostly of ancient cut; bearing still more ancient labels, and clothed in one of these they pass, each to his appointed place.

THE ANATOMICAL RECORD, VOL. 11, NO. 6
JANUARY, 1917

It is an arrangement of convenience mainly, but the dead hand of these labels often lies heavy on us and may become even a misdirecting influence.

When we turn to human anatomy as a practice, we find that it began without technological affiliations—as a pure science so to speak—and only later became fundamental to surgery. When that branch of medicine developed, and—despite the absence of anesthetics or the control of sepsis—was pushing forward, with speed in operation as the great desideratum, the cultivation of gross human anatomy as a body of ever ready knowledge was most intense.

With the dawn of the modern era in surgery, its importance as a mass of minute information carried with much effort, diminished, for the facts came to be excellently recorded; the surgeon and the professional anatomists worked together and speed ceased to have its former significance. Moreover anatomy had reacquired something of its earlier and broader point of view.

From the nature of the case human anatomy is purely descriptive, and for various reasons has remained almost exclusively a medical cult. Let us see then how our Association of Anatomists stands in relation to this subject, when it is narrowly defined.

Out of 323 members we have 146, or 45 per cent, connected with departments of human anatomy in the strict sense.

Going a step further and examining the first fifteen volumes of The American Journal of Anatomy—where the larger portion of the purely anatomical papers is printed—we find that there have appeared 300 papers in all. These I have analyzed by groups into those dealing with gross human anatomy; with mammalian embryology; and with other topics.

Subdividing this last group into those purely descriptive and those including experimental work.

By this treatment it appears that 11 per cent are on gross human anatomy; 40 per cent on mammalian embryology and 49 per cent on other topics. Thirty-five per cent within the last group being purely descriptive, 14 per cent including experimental work.

In this connection it should be remembered that while The American Journal of Anatomy contains almost all of the papers on human anatomy which are presented to us yet the papers on other topics tend to appear in different journals.

That the foregoing proportions represent fairly well what has been going on is indicated by the fact that an analysis of our programs for the same period shows a similar distribution of the papers. In all, there have been 558 titles presented at our meetings and the proportion for human anatomy rises, by virtue of the presentation of several papers on the brain and on anthropometry, to 16 per cent.

Taking then these two determinations for the work on human anatomy at their face value it appears that this subject is represented in The American Journal of Anatomy by 11 per cent of the papers, and at the meetings of the Association by 16 per cent of the titles—there being 45 per cent, or nearly half, of the members of the Association who are also members of departments of human anatomy.

The reason for this seeming disparity is not far to seek, for even a hundred years ago we find men like old John Barclay of Edinburgh rather desperate over the anatomical situation.

Before going further however, let me add here a few words intended to forestall any misinterpretation which might be made of the preceding paragraphs.

These paragraphs are not intended to be in dispraise of human anatomy, nor as questioning either its paramount importance, nor the debt we all owe to those who have put the facts in order and made them accessible. Neither by my statistics would I imply that the anatomical members of this Association have failed in loyalty to their subject.

The implications of the old name do hamper us however, and I wished to point that out, by showing, as I have done, how one could apparently demonstrate that the Anatomical Association was not attending to anatomy. On the other hand it was important to emphasize the accepted fact that human anatomy, in the historic sense, has been so carefully worked over and is so strictly descriptive, that today the human

body, though very completely known, is not the material with which we can work most advantageously in the solution of many biological problems. Appreciation of this fact has led to action and there is therefore a tendency to overstep the earlier and narrower bounds, to escape the ancient barriers and to annex the surrounding country. This tendency appears in our programs; but of these matters—later.

The fairest conclusion from such a survey, is this: To any group of active biological workers it is hardly possible to give a descriptive name—fixed by statute, so to speak—which shall hold good for any length of time and be an indication of their intellectual aims for the guiding interests of such a group are bound to change from decade to decade, if not more rapidly.

This Association illustrates most clearly such a shift of interest. Those who founded it (1888), and those who watched over its earlier development, felt constrained to retain the term anatomy—but at the same time sought to give to this term a wide and elastic meaning—a meaning, if you will permit the paradox, almost too useful to be formulated. As the association grew, both comparative anatomy, mammalian embryology, and physical anthropology were brought in to broaden the field of work and widen the scope of interest.

Through embryology the common origin of organs and systems is revealed and the form relations of the adult explained. Comparative anatomy has shown the correlation of form with function, and by it the phylogenetic relationships of man have been made evident.

But aside from advances of the sort just cited, the chief virtue of this more generous interpretation of anatomy has been to emphasize the fact that the animal body is in a continual state of flux and change, even from the structural standpoint.

The moment attention is directed to the fact of change—be it ontogenetic or phylogenetic—the inevitable tendency is to endeavor to determine how such change occurs—and this leads to experimental work with the attempt to relate the character of the process to the details of the accompanying structural alteration. Fortunately studies which include experimental

modifications have been welcomed at our meetings. The analysis of the programs shows an average of 14 per cent of experimental papers up to 1910 and from that date on, an average of 32 per cent—a very notable increase.

We shall agree, I believe, that a broad policy should be maintained and the presentation of work of this character encouraged.

Such an attitude, however, desirable as it may be, does not meet our needs completely. It is also important for us to push further on in the direction in which these first steps have been taken, and I regard this occasion as an opportunity to say something concerning the course and character of this coming effort.

We shall all admit that the ultimate problems of biology lie in the field of function. The investigator aims to control, to explain and to foretell activities, and in this connection it is fitting to recall that it comes down to us from Aristotle that the most important question concerning an animal is how it lives—not what it looks like.

The functional phenomena are naturally the most important, first because of our deep interest in the dynamics of human life, and second because as we progress in the study of function, we pass from the cell—the unit of structure—to the more precise units of chemical activity, and these latter studies are thus made in the terms of the most fundamental masses yet recognized.

When functional processes are expressed by a formula, the animal sometimes appears a bit superfluous, but a description of the structures involved is generally required to complete the picture.

All physiological reactions imply structure—for the cells are the loci of the activity. To be sure only a portion of the structural peculiarities of cells is ever visible, but when studying the activities of an animal or its organs or tissues, it is of fundamental importance for us to possess the most detailed information available concerning the structural make up of that which is being tested.

Thus interest in function normally carries with it a like interest in structure, and conversely structures which have known

functions become those worthy of the most intense study from the standpoint of anatomy.

Apropos of this aspect of the question before us, permit me a word on the subject of general physiology. The study intended to discover the laws of living substance, wherever found, was well started on the continent in the early seventies—but just at that time the many problems in morphology and phylogeny brought into prominence by the work of Darwin, diverted the young men of the period—and nearly a generation had to pass before the subject was again taken up and developed as we find it today. For us the interest of this earlier endeavor lies in the fact that it was based on a sound knowledge of structure and represented the sort of appreciation of the inter-relations of form and function—for which I would here make a plea.

Of course, since anatomy and physiology received their present elaboration, it hardly has been possible for individual workers to command, even in limited fields, either the experience or the information that would make their results equally valuable from both points of view. In a sense this state of affairs has come to stay—but on the other hand it is mitigated by the fact that scientific progress is accompanied by something more than the heaping up of many details. Definite conclusions emerge and generalizations are established, so that considered as usable information, the accumulated data gradually become more and more available for those not immediately occupied with the initial experiments or observations.

As students of structure it is important for us to utilize the physiological information thus prepared, for in many cases it gives the significance to structural features which is needed to make those features intelligible.

Despite the close interdependence of form and function, there often appears a curious antagonism between the workers in these two fields, an antagonism that amounts almost to a contempt for the kind of work done by the other man. When each is following his own line narrowly—be he concerned with function or with structure—I am not sure but that the antagonism is justified. Yet all work is not necessarily as restricted

as the conventional labels might suggest, and so far as any work in either field is broad, it is not open to hostile criticism solely by reason of its major content.

If then, we break through historical limitations, and as anatomists extend our interest to the entire vertebrate series—including in the case of each form everything between the germ cells and the senile animal, and if in our descriptions we recognize functional phases which are more or less under control, and on occasion exercise such control, we have marked out for study a field which includes all of the general biological problems, and which also may be approached from the angle of our special interest.

Speaking in concrete terms we may put the case as follows: Given an animal the biological questions which it raises can be enumerated thus:

Its systematic position; its place in the palaeontological series; its distribution; its ecology; its behavior; its heredity; its functions in the terms of tissues and organs—including the chemistry of the energy interchanges; its structural features from the ovum to the senile animal, in terms not only of gross anatomy, but also in the terms of constituent cells and cell structure, as well as in physical or chemical terms. These represent the concrete problems while over and above them floats the great cloud of general questions.

The answers to all the questions thus indicated are to be sought with the idea of comparing the data gathered from the form examined with those gathered from other forms, for the purpose of obtaining general conclusions. Such a program calls for a good deal of downright description.

Every biological investigation falls somewhere within this general frame, but in each instance has its own peculiar affiliations and its special goal.

If we turn now to the question of the direction in which our work as an association might move with advantage—it is necessary to clear the ground a bit before passing to particulars.

In the first place it is self evident that biological work is bound to produce results applicable to man—and these results will

some time or other be added to our store of common knowledge. All our work moves that way just as steadily as our solar system moves towards the constellation of Lyra—though unfortunately not so fast. This definite trend need not worry us, for it has no bearing on what we sometimes call pure science.

Pure science is the work of those who endeavor, as they go, to clear up the underlying problems brought to light by their special studies, rather than to press the immediate application of crude results. The practice is largely a question of temperament, and the definition one of degree.

We have seen that traditional anatomy has been vivified by the inclusion of comparative anatomy, physical anthropology and embryology—all of them still very live subjects—but this is no reason why we should not look about for other fields which might also be cultivated with advantage.

Doubtless each of us could present a list of biological topics that might be added to those already enumerated—and it is probable that such lists, while they would largely agree, would always express something of the personal preoccupations of the men who made them.

Thus, were I asked to name some directions in which we might extend our work I should naturally lay weight on post-natal growth in the terms of cell multiplication and cell structure, with its many subsidiary problems, and also on the need for more precise information touching the chemical constitution of tissues and organs as modified by advancing age—for these changes must be of prime importance from the standpoint of function. This illustrates my point. Details in this direction are however not in place at this time, but it is perhaps worth while to emphasize the value to each one of us of formulating with some exactness for himself the general lines of work which might be followed—and of determining their relations to each other—whatever his particular program may be—for when an investigation is to be carried out, these formulations offer the investigator something solid on which he can lay hold.

The question of the direction in which one should move is intimately related to the larger question of what things are worth

while. A common answer to this latter question is that one cannot tell what will be worth while—but I wonder whether this agnostic attitude is quite justified.

If we look on science as coöperative, it follows that our individual work should have some recognizable relation to the larger problems or special interests of our own time, and the worth of our personal activity can, in one way, be measured by the degree to which the worker himself can link with his own activities those of his contemporaries.

I put the statement in this form because others may not at once see the significance of an investigator's work and may even require to have it hammered in, but if the man himself sees it, and in the end can make it visible, he has arrived.

This problem of worth links itself closely with the broad question of the way in which the body of knowledge constituting any science is built up; the question of "the work that lives."

The answer to this last question is simple. The work that lives is that which is useful to other investigators—whether it be an hypothesis, a method or an observation. Other work no matter how brilliant in itself or how remarkable the technical abilities were that lead to its accomplishment, has but an ephemeral existence.

There is on the other hand a sort of ferment action exercised by thorough researches, for when an investigator reaches the point where he is able to offer generalizations, he specially contributes to the advancement of learning, for it follows as one result of his activity that his colleagues will be fairly certain to hunt assiduously for weak points in his work, and thus he acquires in the scientific world the honorable position of an organizer of labor.

If you will look over the titles of any list of classical memoirs in science which have been thought important enough to be reprinted, you will find not only in biology, but in the whole realm of natural science, the sort of work to which I would direct attention.

It is of interest to note that among the investigations thus honored, there is no stereotyped work, characterized by the

accumulation of results without improvements in method, or studies with a time clock attachment or investigations that are prescribed.

The moral appears to be that the effective investigator is a free man: Yet along with this essential freedom must go limitations which are self imposed. As there is no such thing as an isolated idea it follows that in the world of thought it is possible to start from any point and by successive steps of association pass to any other point whatsoever. The investigator is continually called upon therefore to curb his interests or rather his activities—while pushing forward towards some goal which he himself clearly perceives. Thus it happens that the mature research always appears framed and oriented, and the author takes pains to inform us of the direction in which he is moving.

Each fundamental science has at its core a few more or less precise concepts in relation to which it grows. A derived science like biology also has its own central concepts. To add to these concepts or to modify them by extension or rectification is to contribute. To this end descriptive and technical work are both important and necessary, but in the case of biology, there is also the functional side which the student of structure needs to appreciate. Something is gained if he admits it is there, but more if he takes it into serious consideration.

I conclude therefore that although we are entrusted with the grave responsibility of preserving and transmitting anatomical knowledge, and are designated by the ancient and honorable title of Anatomist, yet we are at liberty to reject anything historically implied by that title which might prove hampering to our present work. Nevertheless our group is represented by those trained primarily in the study of structure and such studies must remain our chief occupation.

It is not possible however to contribute effectively to the solution of the larger biological problems unless the functional responses associated with structures are kept clearly in view—or even examined.

So long then as animals or their parts are studied comprehensively by us, we may hope to keep intellectually alert, and it is my conviction that our scientific worth as an association will in the main depend on the persistence with which we follow an inclusive plan of investigation and maintain the broader view.

PROCEEDINGS OF THE AMERICAN ASSOCIATION OF ANATOMISTS

THIRTY-THIRD SESSION

Anatomical Laboratories of Cornell University, New York University and Columbia University, New York City, December 27, 28 and 29, 1916

WEDNESDAY, DECEMBER 27, 9.00 A.M.

The thirty-third session of the American Association of Anatomists was called to order by President Henry H. Donaldson, who appointed the following committees:

Committee on Nominations for 1917: J. P. McMurrich, chairman; G. Carl Huber, George A. Piersol.

Auditing Committee: F. T. Lewis, chairman; S. W. Ranson.

The morning session for the reading of papers concluded with an address by the president, Prof. Henry H. Donaldson, on "Biological Problems and the American Association of Anatomists."

THURSDAY, 12.30 P.M. ASSOCIATION BUSINESS MEETING, PRESIDENT HENRY H. DONALDSON, PRESIDING.

The Secretary reported that the minutes of the Thirty-second Session were printed in full in The Anatomical Record, volume 10, number 3, pages 133 to 269, and asked whether the Association desired to have the minutes read as printed. On motion, seconded and carried, the minutes of the Thirty-second Session were approved by the Association as printed in The Anatomical Record.

Prof. F. T. Lewis reported for the Auditing Committee as follows: The undersigned Auditing Committee has examined the accounts of Dr. Charles R. Stockard, Secretary-Treasurer of the American Association of Anatomists and finds the same to be

correct with proper vouchers for expenditures and bank balance on December 23, 1916, of $264.34. (Signed) F. T. Lewis, S. W. Ranson.

The Treasurer made the following report for the year 1916:

Balance on hand December 21, 1915, when accounts were last audited	$264.09	
Receipts from dues 1916	2222.88	
Total deposits		$2486.97
Expenditures for 1916:		
Postage and telegrams	$40.55	
Printing and stationery	68.15	
Collection and exchange	2.53	
Expenses of Secretary-Treasurer, New Haven Meeting	17.80	
Wistar Institute for subscriptions Journal of Anatomy, Anatomical Record, etc.	2064.00	
Stenography-typewriting	29.60	
Total expenditures		2222.63
Balance on hand		$264.34

Balance on hand, deposited in the name of the American Association of Anatomists in the Corn Exchange Bank, New York City.

On motion the reports of the Auditing Committee and the Treasurer were accepted and adopted.

The Secretary announced that the Committee on Nominations, through its Chairman, Prof. R. R. Bensley, places before the Association the following names: For members on the Executive Committee, terms expiring in 1920, Prof. Franklin P. Mall and Prof. James Playfair McMurrich.

On motion the Secretary was instructed to cast a ballot for the election of the above named officers.

The Secretary presented the following names recommended by the Executive Committee for election to membership in the American Association of Anatomists.

Allen, Erza, A.M., Ph.D., Professor of Biology, *Philadelphia School of Pedagogy, 125 Thompson Ave., Ardmore, Pa.*

Amsbaugh, A. E., A.B., Student of Medicine, *University of California, Berkeley, Calif.*

Bailey, Percival, B.S., Assistant in Anatomy, *Northwestern University Medical School, Chicago, Ill.*

Byrnes, Charles M., B.S., M.D., Instructor in Neurology, *Johns Hopkins Medical School, 207 E. Preston St., Baltimore, Md.*

Carey, Eben J., Instructor in Anatomy, *Creighton University Medical Department, Omaha, Neb.*

Carver, Gail L., A.B., A.M., Professor of Biology, *Mercer University, Macon, Ga.*

Cummins, Harold, A.B., Instructor in Histology and Embryology, *Vanderbilt University Medical School, Nashville, Tenn.*

Dubreuil, G., M.D., Professor of Anatomy, *Institut d' Anatomie, Universite de Bordeaux, Bordeaux, France.*

Eaton, Paul Barnes, A.B., M.D., *1306 W. Lexington St., Baltimore, Md.*

Fisher, Homer G., A.M., Student, *Johns Hopkins Medical School, Baltimore, Md.*

Gee, Wilson, M. A., Ph.D., Professor of Biology, *Emory University, Oxford, Ga.*

Gibson, G. H., M.D., *Waitangi, Chatham Islands, Wellington, New Zealand.*

Holt, Caroline M., A.B., Ph.D., Assistant Professor of Biology, *Simmons College, Boston, Mass.*

Johnson, Sydney E., Ph.D., Instructor in Anatomy, *Northwestern University Medical School, Chicago, Ill.*

Keegan, John J., A.M., M.D., Instructor in Anatomy, *University of Nebraska Medical College, Omaha, Neb.*

Koch, John C., B.A., Student of Medicine, *Johns Hopkins Medical School, Baltimore, Md.*

Kunitomo, Kanae, M.D., Professor of Anatomy, *Nagasaki Medical School, Nagasaki, Japan.*

Latimer, Homer B., A.M., Associate Professor of Zoölogy, University of Nebraska, *1909 South 27th Street, Lincoln, Neb.*

Lewis, Margaret Reed, M.A., Collaborator, Department of Embryology, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*

Morris, Margaret, B.A., Ph.D., *Osborn Zoölogical Laboratory, Yale University, New Haven, Conn.*

Murray, H. A., Jr., A.B., Student, Columbia University, College of Physicians and Surgeons, *437 West 59th Street, New York City.*

Norris, Edgar H., B.S., A.M., Assistant in Anatomy, *University of Minnesota, Minneapolis, Minn.*

Pfeiffer, John A. F., M.A., M.D., Senior Asst. Physician and Pathologist, *Government Hospital for the Insane, Washington, D. C.*

Rasmussen, Andrew T., A.B., Ph.D., Instructor in Neurology, *University of Minnesota, Minneapolis, Minn.*

Ringoen, Adolph R., Assistant in the Department of Animal Biology, *University of Minnesota, Minneapolis, Minn.*

Robertson, Albert Duncan, B.A., Professor of Biology, *Western University, London, Ontario, Canada.*

Rose, Frank H., A.B., Austin Teaching Fellow, *Harvard Medical School, Boston, Mass.*

Schultz, Adolph H., Ph.D., Collaborator in Embryology, Carnegie Institution, *Johns Hopkins Medical School, Baltimore, Md.*

Sharp, Clayton, A.B., M.D., Instructor in Anatomy, Columbia University, *College of Physicians and Surgeons, New York City.*

SMITH, H. P., A.B., Student of Medicine, *University of California, Berkeley, Calif.*
SMITH, WILBUR CLELAND, M.D., Assistant Professor of Anatomy, *Tulane University, New Orleans, La.*
SWINDLE, GAYLORD, Ph.D., Instructor in Anatomy, *Washington University Medical School, St. Louis, Mo.*
TURNER, C. L., B.A., M.A., Instructor in the Department of Anatomy and Biology, *Marquette University School of Medicine, Milwaukee, Wis.*
WHEELDON, THOMAS FOSTER, A.B., A.M., Austin Teaching Fellow, Department of Anatomy, *Harvard Medical School, Boston, Mass.*
WHITTENBORG, A. H., M.D., Professor of Gross-Anatomy, *College of Medicine, University of Tennessee, Memphis, Tenn.*
WILLIAMS, JAMES WILLARD, B.A., M.A., Professor of Biology, College of Yale in China, Changsha, China. (*Care of G. H. Malone, Nanking, China.*)

On motion, the Secretary was instructed to cast a ballot for all the candidates proposed by the Executive Committee. Carried.

Motion was made by Prof. S. W. Ranson, that a committee of three be appointed by the President to consider the matter of nomenclature relating to the Sympathetic Nervous System. Seconded and carried.

The Association passed the following resolution regarding the National Research Council:

Be it resolved: that the American Association of Anatomists hereby registers its approval of the coördination and federation of the research agencies in the country undertaken by the National Academy of Sciences, and expresses its willingness to join with and assist the National Academy in accomplishing the above federation.

In connection with this, it was further moved by Professor Harrison that the Association coöperate with the Committee of One Hundred on Research and the National Research Council and that the Chair designate a Committee to work jointly with other members appointed by the Committee of One Hundred and the National Research Council. Seconded and carried.

On motion the Association adjourned.

FRIDAY, DECEMBER 29. A SHORT BUSINESS SESSION FOLLOWED THE SCIENTIFIC SESSION.

President Donaldson announced the appointment of the following committee to consider the matter of nomenclature relat-

ing to the Sympathetic Nervous System—Prof. G. Carl Huber, chairman; Profs. S. Walter Ranson and Irving Hardesty.

It was then moved and voted that the Association express through the Secretary appreciation of the valuable aid The Wistar Institute is rendering the Association and the progress of anatomy in this country by its most generous and efficient publication of the Anatomical journals. Further The Wistar Institute has contributed greatly to the success of the present and past two meetings by its prompt publication and distribution of the abstracts of the communications presented.

It was moved and voted that the Association express through the Secretary its thanks and appreciation to Cornell University Medical College, New York University and Columbia University for the cordial hospitality and the manner in which the Association has been accommodated and entertained.

CHARLES R. STOCKARD,

Secretary of the Thirty-Third Session of the American Association of Anatomists

ABSTRACTS OF PAPERS

PRESENTED AT THE

THIRTY-THIRD SESSION

OF

THE AMERICAN ASSOCIATION OF ANATOMISTS

DECEMBER 27, 28 AND 29, 1916

AT

NEW YORK CITY

(All papers marked with an asterisk (*) were read only by title)

---

1. The Golgi apparatus in the cells of the distal glandular portion of the hypophysis. WILLIAM H. F. ADDISON, University of Pennsylvania.

The Golgi apparatus in the cells of the distal glandular portion (pars anterior) of the hypophysis of the albino rats is demonstrable by several methods. It is shown in thin sections (3–4 μ) in the basophilic and acidophilic cells. After castration the basophilic cells undergo distinct changes (Anat. Rec., January, 1916) but the Golgi apparatus persists throughout these changes, apparently functioning as a definite cell organ.

The methods used have been the neutral formol-bichromate-sublimate fixation of Bensley, (Biol. Bull., 1910), the neutral formol-bichromate procedure of Cowdry, as well as the special methods—the osmic acid method of Kopsch, and the method of Golgi as given by Kulesch (Arch. f. Mikr. Anat., 1914) and Riquier (Arch. f. Mikr. Anat., 1910). The pictures of the Golgi apparatus given by these several methods are quite comparable although of very different appearance. In the preparations made by the Bensley or Cowdry fixations, the general appearance of the Golgi apparatus may be studied after the usual staining methods—Mallory's aniline blue-orange G., iron hematoxylin, or hematoxylin and eosin. It is of larger size and so is more readily seen in the large basophilic cells. Here it shows as a round or oval condensed spot, surrounded by a lighter ring, situated within the cytoplasm near the nucleus. The surrounding lighter zone is no doubt accentuated by

shrinkage due to difference in density between the substance of the Golgi apparatus and the surrounding cytoplasm. In a three-month normal rat hypophysis, prepared by one of these methods, the basophiles measure 14 μ x 11 μ, with nuclei 6.7 μ x 5 μ. Here the Golgi apparatus measures on the average 5.5 μ x 3.8 μ. In three-month animals which had been castrated two months previously, the basophiles measured 19 μ x 15.5 μ and the Golgi apparatus 8 μ x 5 μ. Thus with the increase in size of the basophiles, the Golgi apparatus has also increased. In the basophilic cells of animals which had heen castrated more than two months, large vacuoles developed. These vacuoles press aside the nucleus and the Golgi apparatus, but the latter retains its definite structure although often somewhat flattened by the enlarging vacuole. In the acidophilic cells, which are smaller in size than the basophiles, the Golgi apparatus is also smaller and hence not so conspicuous. Gemelli, an early observer (Boll. Soc. Med. Chir. Pavia, 1903) pictures much larger structures, which extend as a network throughout a considerable portion of the cytoplasm, but his experimental animal and technique were different.

With the silver methods of Golgi the deposits of silver are within the spots. Often they show as a localized condensed mass but in other parts of the same preparation the black deposit takes on a network aspect. With the osmic acid method of Kopsch, the network appearance is often more sharply defined. What the nature of this appearance may be, is at present a topic of debate, but the fact that it persists when the cell is undergoing cytomorphic changes may be put forward as evidence that it is here a definite cell organ.

2. The behavior of the interstitial cells of the testis towards vital dyes. William H. F. Addison and J. Monroe Thorington, University of Pennsylvania.

On examining sections of testes of animals (*e.g.*, white mice and white rats) which had been previously injected with trypan blue, distinct scattered blue spots are seen between the seminiferous tubules. This appearance was interpreted by Goldmann ('09) as being that the interstitial cells of Leydig had collected the blue within themselves. From our studies it would seem that the blue is not within the glandular interstitial cells, but within other cells, which are of connective tissue types, and which normally compose part of the intertubular cell-masses.

Before Bouin and Ancel ('03 and later) brought forward strong evidence for the hypothesis that the interstitial cells of the testis represented a gland of internal secretion, these cells were regarded as trophic structures, with the function of passing on nutrient material from the blood vessels to the various cells within the seminiferous tubules. In this latter view, Goldmann concurred and believed that he could follow the processes of the interstitial cells forcing their way into the tubules and so purveying granular nutritive substances directly either to the Sertoli cells or to the spermatids. H. M. Evans (Science, '14)

found "in the testis the interstitial cells of Leydig are stained brilliantly although the granules here are singularly regular and intermediate in size between those possessed by cells of types one and two in the skin. In addition, true vitally stained connective tissue cells of type two are present between the seminiferous ducts."

In our series of experiments on male white mice and white rats, in which trypan blue was injected subcutaneously, the reaction to the stain was typical. When thin sections (3–5 μ) of the testes were examined, the blue coloration was seen to be confined within a small number (2–3–6) of cells in each intertubular mass. These cell-masses are often triangular in shape, as seen in cross-section of the testes, and the blue-containing cells were disposed singly and situated, for the most part, at the periphery of, and often one at a corner of the intertubular cell-masses. By counterstaining it was seen that the glandular interstitial cells were free from the dye. The cells containing the blue were of two appearances. Some were elongated in the form of fibroblasts, but the greater number were rounded or polyhedral. These latter from their finely vacuolated cytoplasm and often slightly irregular oval nucleus, might be regarded as clasmatocytes. The nuclei of these were smaller and of more homogeneous appearance than the nuclei of the glandular interstitial cells. According to Evans' definition, both types of cells containing blue would be included under the term macrophage.

Thus by the use of trypan blue it is possible to distinguish between glandular interstitial cells and macrophages in the intertubular cell-masses of the testes of mice and rats.

3. On the origin and fate of the osteoclasts (*lantern*). Leslie B. Arey, Northwestern University Medical School.

Since their discovery by Robin in 1849, the polykaryocytes of developing bone have been regarded commonly as the agents of bone resorption. For this reason these multinucleate cells have been termed 'osteoclasts.'

Views as to the origin of the osteoclasts are not in accord. Kölliker maintains that they arise from osteoblasts by repeated nuclear division; Howell infers an origin by osteoblastic coalescence; Bredichin derives them from fused bone cells; Ranvier, Duval, and Böhm from lymphoid marrow cells; Mallory from fused endothelial leucocytes; Wegener and Schaffer from the endothelium of capillaries; Kaczander from cartilage cells. The results of Jackson, Danchakoff and Maximow agree in tracing the origin of the *first* osteoclasts in the early stage of bone development to enlarged reticular cells of the bone marrow. These cells possess at first but two or three nuclei and the cytoplasm is basophilic. Later their cytoplasm becomes oxyphilic and the nuclei may become extremely numerous.

A variance of opinion exists also as to the resorptive potentialities of the osteoclasts and the manner in which the nuclei increase in number. According to Kölliker and Jackson these cells actively resorb

the bone matrix, while the number of nuclei is increased by nuclear division. Bredichin views the osteoclasts as transitional stages in the transformation of bone matrix into marrow and granulation tissue, with a coincident multiplication of the nuclei of the component bone cells. Danchakoff speaks of the confluence of mesenchymal cells. Maximow believes that large osteoclasts arise at the expense of smaller ones, the multinuclear cell-masses thus formed being ameboid phagocytes. He never observed nuclear division either by mitosis or amitosis. F. T. Lewis emphasizes the absence of direct evidence respecting a resorptive activity on the part of the osteoclasts and rejects their origin by cell fusion. They are rather to be regarded as degenerating cells "produced by those conditions which lead to the dissolution of bone."

Concerning the ultimate fate of the osteoclasts, Kölliker believed that they might resume an osteoblastic function after their resorbtive activity had ceased. Jackson rejects this view and maintains that both osteoclasts and bone cells return to a reticulum similar to that from which he holds they took origin. Maximow differs with Jackson in that some osteoclasts are said to be destroyed through extreme degeneration.

The untimely death of Prof. C. W. Prentiss interrupted an investigation which he had been pursuing on the origin and fate of the osteoclasts, and relative to which he had published a brief note. A reinvestigation and extension of these observations, made by the writer, form the basis of the present preliminary communication. Observations have been made on membrane-bone of human, and especially of pig embryos. A favorable site for study is found about the walls of the dental alveoli where active bone resorption is preparing for the accommodation of the rapidly growing teeth. Here osteoclasts appear in large numbers.

In regions where bone is actively forming the osteoclasts are columnar and distinct with basophilic cytoplasm. During development the cytoplasm diminishes in amount, and in older regions the still basophilic osteoblasts flatten out and form syncytial masses. While the osteoclasts may arise from reticular cells in the early stages of bone development, my observations indicate that in later stages they take origin from the osteoblastic syncytia just described. There were found all transitional stages between these syncytia with basophilic cytoplasm, staining blue with hemotoxylin, and typical oxyphilic osteoclasts staining red with eosin. Furthermore, osteoclasts were seen frequently continuous at either end with basophilic osteoblasts and particularly with osteoblastic syncytia.

According to these observations, therefore, the osteoclasts arise from depleted osteoblasts which have first formed a syncytium before being transformed into the oxyphilic osteoclasts. Nuclear division by mitosis or amitosis has never been observed, although mitoses were not uncommon in the nearby germinative layer of the epidermis. As bone resorption continues, new osteoblasts come into relation with

the osteoclasts and are incorporated into them, so that in general, the larger an osteoclast, the more numerous its nuclei and the more extensive its probable bone resorptive history.

But the osteoblasts, as such, are not the only source from which the nuclei of the osteoclasts are recruited. Bone cells, embedded in the matrix, are laid bare by the resorptive processes and are ingested by the osteoclasts following in the wake. All intermediate conditions may be found between the initial and final stages of inclusion. Furthermore, bone cells are surrounded normally by a capsule which resists the action of strong hydrochloric acid. Encapsulated and distinctly stellate cells, which resemble bone cells, may occasionally be found embedded in the osteoclastic cytoplasm. Such cells are interpreted as bone cells whose capsules are still resistant to cytoplasmic digestion. From the relative infrequency with which persistent capsules are seen it is probable that the enclosed bone cells are eventually liberated. Ingested bone cells must contribute in substantial numbers to the formation of osteoclasts.

Here it appears that the degree of multinuclearity is an index of the number of osteoblasts and bone cells entering into the composition of the osteoclasts.

There is no direct evidence as to how bone matrix (inorganic and organic) is resorbed. One may assume that it is essentially a process of decalcification and digestion through the agency of an acid and an enzyme. The relation of the osteoclasts to these changes can only be inferred. The facts that osteoclasts are plentiful where resorption is going on and disappear when resorbtion ceases, that they are applied closely to the surface of the bone, that they often wrap themselves around irregular spicule-processes or lie in distinct pits (Howship's lacunae), that the surface applied to the bone possesses at times a striate border, and that the staining reaction differs from osteoblasts, all suggest but do not prove a resorptive activity.

A word as to the fate of osteoclasts. That these cells may be resolved finally into osteoblasts and again act as bone-formers seems improbable. My preparations show nothing in favor of such a cycle, whereas pictures of degeneration in varying degrees are abundant. The onset of cytoplasmic degeneration before the cessation of bone-resorptive activity seems to be not uncommon. At times degenerating osteoclasts, singly or in nests, are found stranded in the marrow tissue. These often exhibit extreme vacuolization and other degenerative changes. To a certain extent they probably atrophy and disappear although indications of a transformation into marrow reticulum are not lacking. Large osteoclasts have been observed rarely in the blood vessels of the bone marrow. That such gain admittance, and do not arise *in situ* is supported by their degenerate appearance, due to cytoplasmic vacuolization, granular degeneration and pyknotic nuclei.

Summary. 1. While osteoclasts may form in the early stages of bone development from reticular cells of the marrow, in later stages they arise from syncytia of depleted osteoblasts.

2. The numerous nuclei of large osteoclasts are derived (a) from the constituent osteoblasts, and (b) from bone cells which are ingested as the bone matrix is resorbed.

3. Only indirect evidence points to the osteoclasts as the active agents in bone-resorption; they may also be interpreted as degenerating osteoblasts.

4. Eventually the osteoclasts either atrophy and disappear or are resolved into the reticulum of bone marrow.

4. On the relation between neural and intermediate portions of the hypophysis. (Lantern.) WAYNE J. ATWELL, Department of Anatomy, University of Michigan.

In a study of the development of the hypophysis in the rabbit an intimate association of neural portion and intermediate lobe has been observed. This union of the two parts is first seen in rabbit embryos of fifteen days' development. Not all embryos of this day present the phenomenon, but every sixteen days' embryo examined shows one or more definitely circumscribed regions in which the two parts are in very intimate relation.

The conditions found in rabbit 8 A (sixteen day embryo; 5 μ series) may be taken as typical. The hypophysis region of this embryo was carefully reconstructed in wax and then the neural and intermediate parts were separated. On viewing the model of the neural lobe from the surface which was in apposition to the intermediate part, four distinct areas of contact may be seen. They are arranged in two pairs, one of which is near the caudal, or free, end of the lobe. The other pair lies about midway between the free end of the lobe and the place of its attachment to the brain wall. The combined areas of these four contact regions approximates one-third of the entire surface of the lobe facing the intermediate portion. One of the caudal areas is the largest of the four and no two are of the same size. Embryos which present only one region of contact have that one near the caudal end of the lobe.

From sections it may be seen that the basement membranes of the two parts are lacking at the places of contact. For this reason it is not easy to determine whether the contact is due to the active ingrowth of one part into the other or merely to the passive fusion of the two parts. There seems to be considerable evidence, however, from staining reactions and from the arrangement of cells that the contact is due to the active penetration of the neural portion into the intermediate portion. These contacts, or ingrowths, are, of course, not to be confused with the growth of connective tissue into the gland, which takes place, in the intermediate lobe, about the nineteenth or twentieth day of development.

While every sixteen-day embryo examined presents at least one region of contact, older embryos do not all show them. In certain eighteen, nineteen and twenty-day embryos the two portions of the hypophysis are entirely separate, each showing its own, uninterrupted

basement membrane. Such of the older embryos as do show contact regions have them reduced both in size and in number.

One further observation should be here recorded. On the surface of the intermediate part facing the residual lumen of Rathke's pocket may be seen a slight depression to correspond with the center of each contact area found on the opposite surface of the part.

In attempting to interpret the above-recorded observations for the rabbit the following possibilities present themselves:

1. The contacts or ingrowths may be an attempted ontogenetic repetition of the condition which is normal for certain fishes.

2. An opportunity is offered for the early intermingling of elements of neural and intermediate portions of the hypophysis. On this account, and because of the conflicting statements concerning the adult structure of the part, a careful study of the histogenesis of the intermediate lobe in mammals is very much to be desired.

5. Studies of the cortex of the sheep brain. CHARLES BAGLEY, Jr., Phipps Psychiatric Clinic, Johns Hopkins University.

The purpose of this investigation was to outline clearly the cell and fiber architecture of the sheep brain, with the hope of establishing a foundation for further experiments.

The brain of the sheep was selected for the following reasons: 1) Those interested in cerebral localization have scarcely touched upon the whole group of ungulates and there has been no attempt made to present a complete study of the brain of this member of the group. 2) To facilitate the use of the brain in teaching the anatomy of the central nervous system. 3) The animal lends itself well for experimental study, is easily obtained and can be cared for with but little more difficulty than the more common laboratory animals. 4) The specific starting point was von Monakow's claim of the great size of the frontal lobe and its relation to the red nucleus—a contention which we soon found untenable.

Methods. The plan of attack has been: (a) the study of the brain in phases of development; (b) survey of the cell and fiber structure of the normal adult brain, and (c) experimental ablation.

For the embryological studies serial sections were made of brains of embryos varying from 2 to 47 cm., the latter being about full term.

The architecture of the normal adult brain was first studied in a series of frontal sections of the brain and later in a series of sections made after individual dissection of the gyri—the latter having the advantage of easy orientation and accurate right angle cutting of the laminae.

Experimental ablation of areas previously outlined histologically was done in five lambs (three to five weeks). These brains are now being sectioned and will he stained by the Pal-Weigert method for the study of fiber changes and with various cell stains, to demonstrate alteration in the nuclei of the brain-stem.

Observations. In the embryological series we have outlined the order of development of the sulci and gyri, the period at which cell differentiation is sufficient to present lamination in various portions of the cortex, and the order of myelinization.

The studies of lamination demonstrate five principal areas, connecting which there are narrow zones of cortex of transitional type. The fiber structure also permits of division into areas, but to a less definite degree.

The results of the ablation experiments cannot be stated until further work is done on adult brains, followed by Marchi stains.

**6. The effect of ultra-violet light rays upon the development of the frog's egg: (2) the artificial production of folded (u-shaped) embryos.* W. M. Baldwin, Albany Medical College (Union University).

This paper is the second of a series on the effects of radiation on certain areas of the fertilized and undivided ovum of the frog by means of ultra-violet light rays. The source of energy utilized was an electric arc provided with iron electrodes and actuated by a high-frequency direct current. The illumination of small surface areas of the eggs was brought about by the use of a perforated tinfoil diaphragm. The eggs measured 1.7 mm. in diameter, while the perforations varied from 0.3 to 0.4 mm. in diameter. Consequently, but a comparatively small surface area was influenced in any one experiment. The intensity of radiation was such that an exposure of from twenty to thirty seconds was sufficient to produce developmental defects. The area studied by this method and reported in this paper extended from the region of the equator up to the animal pole, but was exclusive of the pole itself and of a narrow median strip connecting this pole with the equator. The developmental end-product was, in every instance, what is best described as a U-shaped embryo of that general type in which the two folded body-parts lay upon the same horizontal plane.

A singular result of the study of the sectioned specimens, in addition to the striking feature of the uniformity of production of this type of deformity, is the absence of defects in the anatomy of the developed tadpole. Comparatively little has been ascertained concerning the chemical effect brought about by the action of the rays upon the egg mass. Notwithstanding, the conclusion was drawn from studies upon these defective eggs during the process of development that the chemical composition of the cell-mass thus radiated was so altered that it lagged behind in what might be termed the chemical development of the ovum and though ultimately participating in the developmental processes exercised a retarding influence upon some of the gross mechanical shiftings of embryonic anlage. The altered mass, located as it was lateral to the definitive median plane of the embryo, retarded, in the first place, the medianward shifting of the neural tube-half on its own side and induced, in the second place, an exaggerated migration of the opposite tube-half medianward and beyond, towards the affected area, before coaptation with the neural tube-half of that side with the production of a whole tube could be brought about.

7. The development of the serous glands (von Ebner's) of the vallate papillae in man. E. A. BAUMGARTNER, Washington University Medical School.

Serial sections of the vallate papillae in fetuses and new-born form the basis for this paper. Wax reconstructions of the papillae in the smaller fetuses were made and studied.

In a reconstruction from an 8.5 cm. fetus (crown-rump length) the epithelial down-growth forming the limits of the papilla is complete; growing inward from this are three well defined solid bodies, the early gland anlagen, together with less well defined outgrowths. These gland anlagen in a 10 cm. fetus present enlarged ends and slightly constricted stalks, the beginnings of terminal acini and ducts of later stages. The papilla in front of the foramen caecum has many glands extending both from the lower margin and lateral walls of the circumscribing epithelium; at the caudal end of the papilla these glands project backward and downward. The enlargement of the ends and constriction of the stalks is more pronounced in this papilla than in those further forward.

The glands of a lateral papilla of an 11.5 cm. fetus are more numerous in connection with the lateral side than with the lower margin of the circumscribing epithelium, whereas in a 12.5 cm. specimen glands extend downward and backward from the lower border alone. A wax reconstruction of a right anterior papilla shows the glands to be more numerous and longer than in papillae located further caudalward. In one instance a gland is divided near its origin, one of the branches being subdivided.

In several instances in a 15 cm. fetus the enlarged oval ends of glands have divided into stalks and end pieces. Some of the stalks are hollow at their origins from the trench which is now present. The trench surrounding the surface of the papilla is well defined although the shape of the papilla can be readily recognized in younger stages by a slight depression.

A model of a papilla made from a 19 cm. fetus shows the trench well developed and gland ducts extending from its lower rim and lateral walls. One exception was noted, namely a gland duct arising from the inner wall of the trench. Some glands are very short, appearing either as knob-like outpouchings or possessing a short, well developed duct and an expanded but still solid end. The ends in some glands are beginning to show superficial subdivisions separated by grooves, indicating acini. Two or three very long ducts extend downward and outward on the lateral side of the papilla at different levels that give off short tubules which terminate in acinar outgrowths, some hollow, others solid. Some ducts divide immediately into two to four branches. No anastomosing ducts were found. Older specimens (23 cm.) showed ducts spreading laterally, others extending deeply into the muscular tissue before breaking up into glandular tissue.

*8. *The weights of the organs in relation to type, race, sex, stature and age.* (From 115 post mortem examinations at the Charity Hospital, New Orleans, La. Preliminary report.) ROBERT BENNETT BEAN, Anatomical Department, University of Virginia.

The types may be classified in three groups, the hyper-ontomorph at one extreme, the meso-onotmorph at the other, and an intermediate in between. The organs are invariably smaller in the hyper-ontomorph than in the meso-ontomorph, and this difference may be expressed by a number that represents the relative number of large and small organs in each group. This number is a factor that represents the ratio of difference between the hyper-ontomorph and meso-ontomorph in relation to the organ.

TABLE 1

The size of the organs in relation to type

LIVER	KIDNEYS	BRAIN	SPLEEN	HEART	APPENDIX	PANCREAS
6.14	4.10	4.50	4.70	19.00	3.38	4.50

There is greater difference in the heart of the hyper-ontomorph and the meso-ontomorph, and less difference in the appendix. The difference is about the same for the kidneys, brain, spleen and pancreas, but greater than these for the liver.

The differences due to race are determined for the white male and the negro male only. These differences are less than the differences due to type, except in the pancreas.

TABLE 2

The size of the organs in relation to race

LIVER	KIDNEYS	BRAIN	SPLEEN	HEART	APPENDIX	PANCREAS
1.00	0.12	2.33	2.00	0.40	0.50	4.50

The organs are larger in the white male than in the negro male. The numbers given in this and all the tables are obtained by the same method, and indicate relative differences in size. The number is a rough ratio of difference, and any two may be compared with each other in any of the tables.

The differences due to sex are determined for the negro male and the negro female only. These differences are less than those due to type except for the kidneys.

TABLE 3

The size of the organs in relation to sex

LIVER	KIDNEYS	BRAIN	SPLEEN	HEART	APPENDIX	PANCREAS
2.86	3.40	0.60	2.00	14.40	1.30	1.50

The organs are larger in the negro male than in the negro female. The difference is greatest in the heart, and least in the brain.

The differences due to age are less than the differences due to type except in the spleen.

TABLE 4

The size of the organs in relation to age

LIVER	KIDNEYS	BRAIN	HEART	APPENDIX	PANCREAS	SPLEEN
3.50	0.000	1.40	5.15	0.20	0.50	7.75

The greatest difference due to age is in the spleen, and the least in the kidneys. The heart and liver also show differences due to age. More small than large livers, spleens and appendices are found in the old than in the young, and more large than small brains, hearts and pancreases are found in the old than in the young. The brain and heart continue to grow in size with increasing age, whereas the liver and spleen atrophy.

The differences due to stature are considerable, especially for the brain and appendix, in which the differences are greater for stature than for type. The differences in the heart due to stature are unexpectedly small.

TABLE 5

The size of the organs in relation to stature

LIVER	KIDNEYS	BRAIN	SPLEEN	HEART	APPENDIX	PANCREAS
4.85	3.17	13.68	4.87	1.00	6.27	2.40

After all, however, the test of the value of these differences lies in their application to the individual. Is it possible to approximate the size of any organ in the living, if one has the type, race, sex, stature and age of the individual? Let us try a few cases at random. Here is a male negro hyper-ontomorph, aged 52, stature 165 cm. Is the liver large or small? The liver of the negro male should not be so large as that of the white male nor so small as that of the negro female, therefore it should be intermediate in size by race and sex. The age and stature are both intermediate, therefore the type is the most distinctive characteristic. This individual is a hyper-ontomorph and the liver of the hyper-ontomorph is small, therefore the liver of this individual should be small. It weighs 1150 grams which is 350 grams less than the weight of an average or intermediate liver.

Here is a negro male meso-ontomorph, aged 31, stature 169. Is the liver large or small? The race and sex may be disregarded, as before. The stature is only a little above the intermediate, therefore it may be disregarded. The age and the type both indicate a large liver, and the actual weight is 1580 grams.

Here is a white male hyper-ontomorph, aged 50, stature 157. Here the liver should be small but it weighs 2270 grams. The pathological record reads, "amebic abscess of liver," "syphilis of liver." Either one would make the liver weigh more than normal.

Here is a white male meso-ontomorph, aged 56, stature 170. The liver ought to be large and it weighs 2020 grams.

A negro female hyper-ontomorph, aged 36, stature 150, has a liver that weighs 1480 grams which is a little larger than expected.

A negro female meso-ontomorph, aged 18, stature 173, has a liver that weighs 1750 grams, which is about what to expect.

I have gone over the records of the 115 post mortems in this way and in only a few cases was there no explanation of the weight of the organ. If all the factors in each case could be known the weight of each organ might be determined with a fair degree of accuracy during the life of the individual, and the most important factors for such determination are given above.

9. A case of a persistent vitelline vessel in a human adult. ALEXANDER S. BEGG, Harvard Medical School.

Attention has repeatedly been called to the persistence of the vitelline vessels as slender cords in certain mammals, particularly in Carnivora, but strange as it appears, reports of cases of such persistence in the human adult are very few. In the time at my disposal, I have found reference to but two cases comparable with the present one. Of these, the first was that described by Spangenberg in 1819, and the second by Hyrtl in 1859. Spangenberg describes his case as showing a vein, while Hyrtl's case, in a child, showed an artery and an accompanying vein. The above papers, together with those of Meckel and Fitz, that of Broman and the more recent exhaustive work on "The umbilicus and its diseases" by Cullen, have been consulted.

The present case was found in an adult female subject in the dissecting rooms of the Harvard Medical School and was kindly given me by Professor Warren for further study. Upon opening the abdomen a strand was noted which ran free from the inner side of the ventral body wall, 5 cm. below and slightly to the right of the navel, down into the pelvis and up amongst the coils of the intestine. The strand was 30 cm. in length and throughout the greater part of its extent was only of the thickness of a coarse thread. The inner end of the strand was attached to the ventral surface of the mesentery at the level of the sacral promontory. Upon taking that portion of the ileum which is 60 cm. from the colon and drawing it forward, the free strand was seen to enter the mesentery midway between the intestinal tube and the dorsal attachment of the mesentery at the level of the promontory. From the mesentery the strand ran downwards crossing in front of the ileum and to the left of its terminal portion, and then turned upwards to join the ventral body wall as stated above. The cord was visible beneath the parietal peritoneum and was seen to terminate in relation to the obliterated right umbilical artery, near the umbilical ring. At

both mesenteric and umbilical extremities the strand became decidedly thickened. Thus if the slender middle portion had become obliterated, there would have remained an appendix meso-ilei, 3 cm. long, and an appendix umbilicalis of 12 cm. (using the terminology proposed by Broman).

The intestine showed no diverticulum, but the strand was directed towards a point on the ileum approximately 500 cm. from the pylorus and 60 cm. from the colon, a region where the remains of the vitelline duct might be expected. There was no trace of an appendix meso-duodeni (Broman) to indicate the former position of the vitelline vein. In fact, no other abnormalities were observed except certain pathological adhesions and the fissures on the under side of the liver indicated that the umbilical veins had been normal.

Upon injection of the superior mesenteric vessels a small branch of the artery was found to enter the proximal end of the strand, but the mesenteric vein showed no corresponding branch. An attempt at injection of the distal end of the strand, through the epigastric artery, was unsuccessful. In Hyrtl's case there was an anastomosis between the persistent vitelline artery and the deep epigastric artery, but such a connection could not be demonstrated in the present case.

An examination of the models made by Dr. Papez seems to show that the strand in the specimen under discussion represents an uncomplicated persistence of the sheath of the vitelline artery, together with a portion of the vessel itself. In Hyrtl's case the artery in a corresponding strand was accompanied by a branch of the superior mesenteric vein, which would seem to be a new formation rather than a persistent vitelline vein. In Spangenberg's case a strand apparently in the same situation is said to have contained a vein only, but this does not accord with normal embryological conditions. The specimen here described is therefore particularly satisfactory since it can be fully interpreted embryologically.

10. Vestigial gill filaments in chick embryos. (Lantern.) EDWARD A. BOYDEN, Harvard Medical School.

Since the researches of von Baer, the branchial region in the Amniota has interested biologists as supplying the most conspicuous evidence that the higher vertebrates recapitulate, in modified form, stages in the life-history of their ancestors. Apparently no record has yet been made of structures on the branchial arches of higher vertebrates which could in any way be interpreted as functional or rudimentary gill filaments. While studying the anatomy of the 5-day chick my attention was attracted to ectodermal proliferations, protruding from behind the hyoid arch, which seemed to be involved in the obliteration of the cervical sinus. To Prof. F. T. Lewis I am indebted for the suggestion that these projecting cell clusters might be brought into line with the gill filaments of amphibians and fishes. Subsequent study of older and younger chick embryos, together with the finding of similar structures in turtle embryos, seems to warrant a presentation of this material from a phylogenetic standpoint.

The life history of these filaments, covering a period from the fourth to the eighth day, embraces nearly one fifth of the total period of incubation. Throughout this time the epithelium of the filaments themselves as well as the branchial epithelium which gives rise to them is characterized by the presence of what appear to be degeneration vesicles. These accompany, and thus may be said to register, an activity of the epithelium of which the filaments seem to be the fruition. They first appear, as early as the 76-hour stage, in the posterior walls of the first three pharyngeal pouches at a time when the first three gill clefts have broken through and the fourth pouch touches the ectoderm. When complete, each vesicle is a clear, spherical cyst embedded within the epithelium, containing pycnotic nuclei and cellular fragments. Favorable sections indicate that these cysts result from the nearly simultaneous disintegration of several adjacent epithelial cells.

Following their first appearance, scattered vesicles may arise in the walls of all the pharyngeal pouches and in the ectoderm between the clefts on the outside. About the end of the fourth day they are most numerous in the ectoderm between the second and third clefts and are sufficiently abundant to give it a punctate appearance. Eventually some of them are crowded downward into the underlying tissues. A second, less conspicuous concentration area occurs in the ectoderm between the third and fourth clefts. It is of interest to note that it is the ectoderm of these two arches in frogs and toads which forms the first external gills. Again, recalling the fact that vesicles in the chick first appear in the entoderm, it is well known that a proliferation of entodermal cells in the anura precedes the formation of the gills, but instead of producing vesicles as in the chick, tends to spread out beneath the ectoderm as a secondary layer.

At the beginning of the fifth day the ectoderm covering the third arch, where the vesicles are most abundant, has become considerably thickened and is beginning to produce filaments. As viewed from the outside this arch is wedge-shaped and its downward directed point is the first part to develop filaments. Later the upper portion will also give rise to tufts of cells. In a 12-mm. embryo slightly older than the last, the middle of this wedge actually forms an outpocketing which contains a mesodermal core, thus almost reproducing the early formation of external gills in the Amphibia. In this same embryo the ectoderm of the fourth arch forms an evagination, which however is solid and much smaller, and tends to fuse with that from the third arch.

During the remainder of the fifth day the hyoid arches meet in the mid-ventral line and begin to grow backward over the posterior arches, as in the Anura, in the form of a gill-cover or operculum. It carries with it, on its under surface, the tufted epithelium of the third arch, and from now on the filaments of this region of fusion will appear to come from under the surface of the operculum. The filaments attached to the operculum will always be the largest of the series and persist the longest. Differentiation lateral to this point on each side continues

slowly, until, toward the end of the sixth day, there is a transverse line of filaments on either side extending in a dorsal direction part way across the neck. In the next few hours this may be supplemented by a ventral extension of filaments along the under surface of the operculum until in some specimens they nearly reach the mid-ventral line. It is about this time that the larger filaments regularly show branching. This period of maximum extent in the first quarter of the seventh day is followed by a rather rapid decline, until, at the end of this day, all trace of operculum and filaments has disappeared. Coincident with this decline is a curious median proliferation of epitrichial cells in the cardiac region. This is being studied further, but apparently has no connection with the subject under discussion.

By way of a summary the life history of these vestigial structures may be divided into five stages: 1, the *appearance of degeneration vesicles* in the branchial epithelium; 2, the *concentration of these* in the ectoderm covering the third arch and, to a lesser extent, that covering the fourth; 3, the *thickening of the ectoderm* of these two vesiculated areas into tufted epithelial mounds, and, in the case of the first, an apparent *evagination* of the ectoderm with a mesodermal core; 4, a gradual *differentiation of these areas* (now crowded into one and fused with the sides of the backward growing operculum) *into a transverse line of filaments* on each side of the neck; 5, a rather *rapid reduction* of this line and the eventual suppression of both filaments and operculum.

In conclusion, attention should be called to the recent experiments of Ekman ('13) which have a bearing on this problem. He was able to show by transplantation methods that the ectoderm of the branchial region of frogs and toads has a certain specificity for building gill filaments not possessed by the remaining ectoderm of the embryo; that a polarity of this ectoderm could be demonstrated; and that even when the entoderm and mesoderm underlying the future gill region were removed the ectoderm alone could produce abortive filaments. It is the ectoderm of this same region in reptiles and birds which produces rudimentary filaments and they bear a striking resemblance to some of the abortive structures produced experimentally in Amphibia by Ekman. In the case of higher vertebrates the process never passes beyond the initial stages, as evidenced by the early appearance of degeneration vesicles and the failure of blood vessels to participate in gill formation.

11. Development of the preoptic part of the forebrain of Amia calva. Chas. Brookover, University of Arkansas, Little Rock.

In connection with a study of the adult brain of Amia it was thought best to model some stages of the development of the forebrain in order, if possible, to bring it and the closely related divergent forebrain of the teleosts into closer harmony with the ancestral vertebrate brain. The early stages, as expected, show a simpler and more diagrammatic condition than the adult.

The earliest stage modeled is 5 mm. long, taken at a time just before hatching. The embryological condition of an epithelial tube exists. It is bent so as to throw the pineal anlage to the anterior and is but slightly thickened in two places on either side of its basal part. The anterior swelling into the neural canal is beneath the fibrous connection with olfactory placode and goes later into the formation of the olfactory bulbs. The posterior one is the derivative from which comes the remainder of the preoptic forebrain. A fibrillar zone at the periphery permits mapping out the anterior commissure, the olfactory tracts, the optic tracts and perhaps the habenular tracts (fimbria). On the ventricular surface the slightly thinner pallial portion is marked by upper and lower parallel lines running just dorsad of the lateral olfactory tract. The ventricular sulcus bends caudoventrad to flatten out and be lost in the diverticulum of the optic stalks.

Larval stages of 8 and 10 mm. total length show a previous rapid development of the olfactory centers. The thickness of the olfactory bulbs shows in an external swelling and an internal rhinocoele has been developed. Neuroblasts for the formation of mitral cells have migrated toward the periphery. Posteriorly in the olfactory lobes the cells for the formation of the lateral olfactory area have proliferated. This makes a dorsal swelling. Ventrally the cells keep for a longer time their original position and largely epithelial condition along the walls of the common forebrain ventricle. This ventricular lumen extends forward somewhat beneath the olfactory bulbs but not so far as in the earlier stages where it produces what has been called an unpaired olfactory placode.

The above mentioned cells along the ventral portion of the forebrain ventricle are continuous without line of demarcation into the rhinocoeles and here the cells of the nucleus olfactorius anterior of authors are proliferated. In the forebrain this undifferentiated epithelial zone extends posteriorly over the commissure into the thalamus. The medial olfactory tract somewhat belated in its development comes into relation with the anterior part which develops into the nucleus of the precommissural body. This is not exclusively olfactory in function. The nervous terminalis passes through it and the ascending fibers to the olfactory bulbs originate from it in some forms. Golgi preparations of larval Amia at this age show ascending as well as descending fiber connections between this region and the thalamus. Fishes of 22 mm. and of 47 mm. length have a ventricular sulcus extending from the rhinocoele dorsocaudad to the neighborhood of the velum transversum. This sulcus (limitans telencephali) becomes less evident with age and the pressure of opposite sides of the hemisphere on each other. This pressure is due to the large lateral and medial olfactory areas lying dorsal and lateral to the sulcus, as well as to the striatum (paleostriatum) lying laterally.

At the anterior end of the sulcus limitans the cells of the islands of Calleja originate and migrate laterally into position between the two olfactory tracts. Adjacent and continuous with these within the

olfactory bulbs the nucleus olfactorius anterior proliferate. The olfactory bulbs remain in embryonic (primitive) proximity to the forebrain.

In its middle portion the cells of the region just ventral to the sulcus limitans give rise to the paleostriatum. At its caudal end near the velum transversum three nuclei connected to the habenula originate from the ventral edge of the sulcus, viz., the nucleus theniae carried laterally in the eversion of the hemispheres, the nucleus lateralis commissuralis (Sheldon on the carp), and a thalamic nucleus remaining in its primitive position near the ventricle. The second may be connected only with the ventral lobe of the habenula.

The forebrain of Amia is primitive in the proximal position of its olfactory bulbs and the location of its nonolfactory centers near the ventricle but specialized in its hypertrophied olfactory nuclei with strong habenular connections.

**12. Histological differences between certain muscles of the cat as related to physiological and chemical differences.* (Lantern slides.) H. Hays Bullard, Pathological Laboratory, Johns Hopkins University.

The object of this paper is to call attention to some morphological differences between certain muscles of the cat which are believed to correspond to a number of the physiological and chemical differences in the same muscles set forth by Lee, Guenther, Meleney, Scott and Colvin in a series of interesting papers appearing in The American Journal of Physiology, May, 1906. In one of these papers (Lee, Guenther and Meleney) it is mentioned that the authors could find in the literature no comparative histological study of the muscles under discussion, namely, diaphragm, extensor longus digitorum, sartorius, and soleus. From their own histological observations they were not able to point out any striking differences between the given muscles.

In the present experiments these four muscles from twelve cats (young and adult) have so far been examined. The tissue was fixed in 20 per cent formalin and frozen sections were stained with Sudan III by Herxheimer's method. This method is well adapted to the demonstration of the dual structure of muscle as seen in the so-called light and dark or cloudy fibers. The occurrence of an intermixture in varying proportions of these two types of fibers in the skeletal muscles of many animals, including probably all vertebrates, has been known for a long time (Knoll). As is also well known light fibers usually have a few small fatty droplets in their cytoplasm. Dark fibers have many larger fatty droplets. Intermediate fibers also occur which are likewise fatty and probably belong to the dark type.

The four different muscles of the cat may be characterized, briefly, as follows: *Diaphragm.* Light and dark fibers in about equal number, small number of intermediate fibers. Average diameter of fibers less than in other three muscles. *Extensor digitorum.* Light fibers form more than half the total number, dark and intermediate in about

equal number. Average diameter of fibers greater than in diaphragm and less than in soleus. *Sartorius.* Dark fibers predominate, intermediate and light fibers in about equal number. Average diameter of fibers greater than in diaphragm and less than in soleus. *Soleus.* Intermediate fibers predominate, dark fibers in considerable number, light fibers either absent or of very infrequent occurrence. Average diameter of fibers greater than in the other three muscles.

In all four muscles light fibers are of greater diameter than dark. When these four muscles, only, are considered the microscopical picture of each is usually sufficiently characteristic to permit of its identification. From the predominance of intermediate and dark fibers it is always possible to identify the soleus, in transverse section, from a single low power field. The predominance of light fibers serves for the easy identification of the extensor digitorum. The diaphragm and sartorius are frequently identified only after several fields are examined and, exceptionally, one of these muscles is mistaken for the other.

The extensor digitorum and sartorius are macroscopically pale muscles. The soleus is a red muscle and the diaphragm is intermediate in color. It is not true, however, that the dark fibers of the soleus are the cause of the dark or red color of that muscle. Dark fibers have their characteristic appearance only when seen by transmitted light under the microscope. By reflected light they appear light. It follows that dark fibers tend to make the muscle appear pale and the dark red color of the soleus is not due to its dark fibers. Also it is known that many pale muscles are composed largely of fibers that are microscopically dark.

The extensor digitorum, according to Lee, is characterized by great irritability, a short latent period and quick contraction and relaxation while the soleus is less irritable and after a longer latent period it contracts and relaxes slowly. As mentioned above the histological picture shows a great predominance of light fibers in the quick muscle (extensor) and a predominance of intermediate and dark fibers, with almost total absence of light fibers, in the slow muscle (soleus). The diaphragm and sartorius occupy an intermediate position both in these physiological properties and in the relative number of light and dark fibers. It is not probable that these facts are unrelated.

In the present experiments the histological findings in respect to the relative fat content of the four muscles agree with the chemical analyses of Lee. The entensor digitorum, both chemically and microscopically, shows considerably less fat than do the other three muscles. Moreover the quantity of fat microscopically demonstrable in each of the muscles is so great that it would appear to account for the entire quantity shown by chemical analysis. This is not in accordance with the accepted view that much of the fat in the tissues is chemically combined and not capable of microscopical demonstration.

In fasting animals, Lee has shown that the total working power of the diaphragm is reduced by 44 per cent while the working power of

the extensor is reduced by 16 per cent. It is known that fat gradually disappears from the fatty dark muscle fibers of fasting animals (Knoll, Bell, Bullard). As we have seen the diaphragm of the cat contains many more fatty fibers than does the extensor. When the fat is removed by starvation one would expect the diaphragm to undergo a greater proportional reduction of working power.

It is scarcely necessary to mention that the microscopical differences between the four muscles under discussion are not here considered exhaustively. Interesting details respecting nuclear and myofibril characters, occurrence and distribution of mitochondria and glycogen, blood and nerve supply, and connective tissue distribution, all remain to be investigated. A study of the length of the muscle fibers by the methods recently described by Huber might also prove of considerable interest.

There is good reason to believe that the striking physiological and chemical differences which Lee and his collaborators have demonstrated in these four muscles are paralleled by no less remarkable morphological differences.

13. Some factors regulating growth. Montrose T. Burrows, Department of Pathology, Johns Hopkins University.

The problems under consideration in this paper are (1) the nature of the immediate conditions which lead to the failure of scar formation in many wounds or following many extensive inflammatory processes and (2) the general nature of the conditions which inhibit or allow the growth of connective tissue. It is well known that the most extensive inflammations of epithelial surfaces, as pneumonia, are most often followed by complete healing, while inflammations of the deeper connective areas are most frequently followed by the formation of a scar. In cancerous processes the connective tissue cells grow wildly at the expense of other parts.

Hertzler, a few years ago, came to the conclusion that the fibrinous exudates which forms in a wound, is the direct stimulus for the growth of the connective tissue cells. He noted that skin grafts take only when they become imbedded in a layer of coagulable exudate. He also thought that the fibrin fibrils were transformed directly into the extracellular connective tissue fibrils. He had come to this last conclusion by means of a careful chronological study of intestinal adhesions and wounds induced by mechanical means in young rabbits of the same litter. He noted that previous to healing the fibrin is laid down in the form of fibrils. Connective tissue cells migrate among these fibrils. At a later period he found the fibrous tissue fibrils to occupy the same position and have the same arrangement as the fibrin fibrils. The wounds and adhesions had been removed at regular intervals, sectioned and stained. He was unable to see any evidence of the disappearance of fibrin, and the laying down of the connective tissue fibrils. Similar experiments were also made with wounds. In the summer of 1908, the author had the opportunity to study these experiments with Dr. Hertzler.

In the early studies of tissue culture made at Cornell University Medical College, it was noted that the fibrin fibrils in many of the cultures, after a considerable growth of connective tissue cells, stain the characteristic pink color, of white fibrous tissue with Von Gieson stain. These observations were communicated to Dr. Hertzler, who reported them with his own studies ('13). Recently, Baitsell ('16), in Harrison's Laboratory, has made similar observations in tissue cultures. He did not observe the characteristic color reaction with Van Gieson stain.

Whether or not these pink staining fibrils that had been observed in the tissue culture could be considered as true fibrous tissue, or merely structures simulating these fibers in their ability to absorb dyes, was a problem of interest. One of the objections to accepting them was the inconstancy of the appearance of pink staining fibrils in many of the cultures.

In later studies of the growth of tissue in vitro several facts have been found, however, which would tend to substantiate this particular view. The first is that clot contraction or the formation of fibrin fibrils in the cultures of chicken tissue in plasma occurs only in the presence of connective tissue cells. Chicken plasma, when carefully prepared, free from previous tissue contamination, clots with the addition of a fragment of tissue to form a practically structureless jelly-like mass which has the same volume as the original fluid plasma. Any type of tissue conditions this primary clotting. In the presence of living connective tissue cells the clots later undergo contraction, while in the presence of epithelium they may undergo contraction but later liquefaction. Leucocytic or lymphocytic cells cause only slight liquefaction of these clots and very little, if any, contraction.

The second fact is that this contraction takes place only in the presence of living connective tissue cells and then only after a considerable latent period. It fails entirely when the oxygen is replaced by nitrogen or hydrogen. It also fails when the tissue fragments have been heated for five minutes at 60°C. *In other words, it is evident that clot contraction is a phenomenon instituted by conditions quite different from those of primary clotting and it is a phenomenon which is brought about by the action of the products of metabolism of the connective tissue cells.*

At another time the author studied more carefully the properties of the connective tissue cells. He has found that the cells of higher animals are not highly organized, but fluid-like systems. Their various manifestations of life such as movement, growth, etc., are differential surface tension phenomenon under the control of a specifically organized environment. The food materials or energy producing substances in the cultures are not derived from the medium, but from the cells within the fragment. The growth that one observes in the cultures is none other than a simple transfer of materials from the cells of the center of the fragment or in a less favorable environment to those on the periphery or those which have been carried out into the medium through the interchange of substances between the fragment and the

medium. This was shown by the fact that the cells can be grown in simple salt solution and, in the plasma cultures, growth cease after a few transplants, the sum of the total growth being less than the original mass—or it represents what one might assume the original mass minus the energy of transfer. The cells that tend to break down in the fragment and lead to the greater growth of the connective tissue cells are not the connective tissue cells but the epithelium, muscle cells, etc.

Again it was noticed that this growth takes place only in the presence of oxygen. It commences after a given latent period in the case of connective tissue, subsequent to the contraction of the clot). The cells grow actively for a time gradually to come to rest. This reaction is one which apparently commences subsequently to the slow diffusion of substances between the fragment and the medium and proceeds until an equilibrium is established. In other words, it follows the curve of reaction of a heterogeneous physical chemical system. The cells at the end of this reaction do not undergo, at least for a considerable time, any further change. They show no immediate disintegration. That this cessation of growth is not due to the exhaustion of oxygen or food materials is further shown by the failure of any change in the cells following the introduction of fresh air into the culture chamber, and by the fact that activity is again seen when the cells are transplanted to a new culture medium. On the other hand, that it is due to the accumulation of waste products is shown by the fact that the cells which tend to survive for the longer periods of time are invariably those cells which had grown out into the clot and have become completely surrounded by the contracted fibrin. It was of general interest in making these observations to note that this equilibrium which had been established in the tissue culture did not alone concern the cells which had migrated out and grown in the culture medium, but likewise those which remained within the fragment. With the cessation of growth of cells in the outer medium, disintegration with the liberation of energy-producing substances in the fragment also ceases. This is especially true when the fragments have been placed in thick layers of plasma, so that they have become likewise completely surrounded by contracted clots, Many such cultures were kept for as long as six months at incubator temperature and in an ample supply of oxygen before any disintegration became apparent. Several were transplanted at this time and an active growth of cells was observed. The growth of the connective tissue cell is apparently a tissue and not a cellular reaction. The failure of the connective tissue cells to dissolve the fibrin and their ability to transform it into fibrils, leads to the belief that these fibrin fibrils form the superstructure upon which, or out of which, the connective tissue fibrils are built. We observed pink staining fibrils only in cultures of skin of foetal chickens. Whether the formation of the connective tissue fibril is a body, rather than a connective tissue, cell reaction is a question for solution.

It is well known that the growth of cells in the animal organism is not determined alone by food and oxygen but by other unknown

conditions. The question naturally arises, have these unknown conditions been found. Are the actual waste products of metabolism of these cells, substances which are insoluble in body fluids and is the cessation of growth of a part, the result of the accumulation of these substances? One may assume that the fibrin fibrils are formed by the action of the products of metabolism of connective tissue cells on the coagulable exudate, and that the cessation of growth in the wound is due to the accumulation of these substances in and about the growing cells. From these observations, one might readily reduce stimulation as any condition which would lead to the reduction of concentration in these substances. The stimulating action of fibrin is due to its ability to absorb these substances. To prove this more completely the author studied rhythmical activity in heart muscle cells as well as the growth of these and of connective tissue cells in plasma cultures so arranged that the media could be continuously washed with a stream of serum. The rhythm of heart muscle fragment in simple hanging drop cultures is invariably intermittent. In the body it is a form of activity which continues throughout the life of the individual. In the cultures, where the media was continuously washed by a stream of serum, the rhythm was not only greatly prolonged up to the time of complete exhaustion of the cells but it continued regular, while the growth of the cells was not changed but similar to that seen in the simple hanging drop cultures. In a former paper before this Society, the author presented facts to show that the contracting, embryonic heart-muscle cell has an organization which one might readily assume capable of splitting these insoluble waste products into simpler substances and of transforming the energy liberated with their formation into work of contraction.

Certain rapidly growing tissues, such as embryonal and rapidly growing tumors grow readily in liquid medium. This growth takes place only near the surface of the liquid. Cells suspended in liquid invariably round off and show no activity. The cells do not grow out into the liquid. It is of interest to note that adult tissues do not, however, grow readily in liquid medium while, on the other hand, they grow actively in plasma.

It was in the light of these facts and the more careful study of the properties of epithelial as well as leucocytic and lymphocytic cells that the general deductions as to the cause of the failure of scar formation in superficial inflammations of the epithelial surfaces was derived. Epithelial cells invariably bring about a rapid dissolution of the fibrine lots. When occurring in considerable numbers in a fragment of tissue, they invariably prevent entirely a growth of the connective tissue cells. That the appearance of organization in the pneumonic lung probably indicates a complete destruction of the epithelium rather than the lack of leucocytes in the exudate was further suggested by the fact that the leucocytic infiltration in deep seated inflammation is frequently as great as in the superficial ones. It is true that the leucocytes of man are richer in ferments than those of

lower animals; the failure to observe any extensive liquefaction about the leucocytes of chickens would not indicate that this did not occur in human beings. On the other hand, it has been found that fragments of human connective tissue containing leucocytes grow readily in plasma clots when they are removed after twenty-four hours from the first culture to a drop of fresh plasma. This is not true of epithelium. The cells continue to liquefy the plasma, even after many transplants, or until they are dead.

These observations are reported not only for the general bearing that they have on the nature of stimulation and the significance of extracellular substances in their relation to life processes, but also for their immediate significance for the better understanding of the actual conditions which regulate the growth of body cells. If these experiments are substantiated, showing as it is believed they do, that growth is inhibited by the accumulation of insoluble waste products and permitted to proceed only by their removal, then the problem of the growth of the cell is brought into the domain of chemistry. Thus problems, such as those that confront us in cancer, are narrowed.

**14. Preliminary report on the normal unequal growth and degeneration in the early ossification centers in the diaphyses of femora of the pig.* Eben Carey, (introduced by F. W. Heagey), Department of Anatomy, Creighton Medical College.

The normal unequal growth of the subperiosteal osseous tissue, and of the degeneration of the hyaline cartilage cells and matrix in the early advancing diaphyseal center of ossification, as in the femur of the pig, have not been made an intensive problem by investigators. As a consequence descriptions of the early development of the diaphyses of long bones are so worded as to avoid clear statements on certain fundamental points. This paper will be limited to the time when the primary subperiosteal osseous lamina, or as it here will be designated, the lamina prima, is fairly well differentiated.

1. Material and methods. The pig was selected for this problem on account of the abundance of material procurable by the proximity of the laboratory to the South Omaha abattoirs. The femur was chosen as a prototype of long bones with two epiphyses; it was also chosen because the ventral, lateral and mesial walls of the diaphysis of the adult femoral bone primarily present a laminar type of formation and not the characteristic Haversian system type as found in the human femur (Foote '11–'16). This report is a part of a more extended study considering the complete embryology of the pig's femur.

The embryos were hardened by both the alcoholic and Zenker's fixation methods. In the former no decalcification takes place and it was used to ascertain the time when the precipitation of calcium salts precludes sectioning. By the latter method the earliest center of ossification is easily decalcified without subsequent subjection to a stronger decalcifying agent. The center of ossification of older bones,

after Zenker's fixation, are prepared for sectioning by von (Ebner's) decalcifying fluid which was used with excellent results. With the latter reagent less distortion, due to the swelling of the collagenous fibers, took place.

Both cross and longitudinal serial sections were prepared of the femora. Some of the sections were stained with Delafield's haematoxylin counterstained with alcoholic eosin, others were well defined with Mallory's connective tissue stain.

2. Inception of period of ossification. In embryos with a crown-rump measurement of between 20 to 22 mm. the cartilaginous femur is approximately 2 mm. in length. It is well outlined, shows certain adult characteristics, and cavity formation has just begun in the tissue lying between the cartilaginous floor of the acetabulum and the head of the femur. In the first step of the formation of the cavity at the knee joint, there is a condensation of the capsular tissue immediately bordering upon the joint and of the perichondral tissue which at this stage covers the cartilages on their articular surfaces as well as elsewhere. The cartilage of the shaft is of the cellular variety and presents an epithelioid appearance. At either extremity the precartilaginous cells predominate.

It is at this stage that the first changes of osteogenesis are noticed. There is an unequal growth of the osteogenetic cells of the Cambium layer of the periosteum, which encircles the shaft. More cells are proliferated and the constriction is slightly deeper on the ventro-mesial aspect than elsewhere. The cellular cartilage begins to appear slightly atrophied and vesiculated, as evidenced respectively, by the more shrunken granular cells and by a few hollow vesicles, immediately underlying the zone of more vigorous proliferation of osteogenetic cells.

The osteoblasts ultimately form the lamina prima or the first embryonic osseous layer encircling the degenerating cartilaginous shaft. This process also begins on the ventro-mesial aspect. The unequal growth of this lamina prima was followed through the 3 mm., 3.5 mm., 4 mm., 4.5 mm. and 5 mm., lengths of the femur, in embryos with a respective crown-rump measurement of 28 mm., 30 mm., 34 mm., 38 mm., 41 mm. These measurements are the mean computed from five series of 8 to 10 embryos in each series.

3. Conclusions. a. On the ventro-mesial aspect of the central osteogenetic cellular constriction there is a more active proliferation of osteoblastic cells than elsewhere. Immediately underlying this zone the processes of atrophy and vesiculation in the cellular cartilage are begun.

b. The lamina prima first differentiates in a 3 mm. femur on the ventro-mesial aspect, quickly encircling the center of the degenerating cartilaginous shaft as evidenced by the growth in a 3.5 mm. length of the femur.

c. There is a more rapid advance of the developing lamina prima towards the proximal epiphyseal line at the head end of the femur than towards the distal epiphyseal line at the condylar extremity of the shaft.

d. Calcification and vesiculation of the cartilaginous matrix and cells, respectively, also advances at a more rapid rate towards the proximal head end of the femur keeping slightly in advance to the rapidly progressing lamina prima.

e. The lamina prima on the ventro-mesial aspect reaches the proximal epiphyseal line before that on the dorso-lateral aspect. This is the case in a 5 mm. femur and the lamina prima is also considerably thicker on the former than on the latter aspect.

f. A lamina secunda is differentiating, in the 5 mm. length of femur, at the central primary constriction peripherad to the lamina prima.

g. A significant fact is that the nutrient artery enters the adult bone in the upper one-third of the diaphysis on its ventral aspect and is directed distally towards the condyles.

REFERENCES

FOOTE, J. S. 1911 The comparative histology of femoral bones. Trans. of the Amer. Micros. Soc., vol. 30, pp. 88–140.
1916 A contribution to the comparative histology of the femur. Smithsonian Contributions to Knowledge, vol. 35, no. 3. Edited by Aleš Hrdlička.

**15. Microdissection studies.* Cell and nuclear division. (Lantern).

ROBERT CHAMBERS, Jr., Cornell Medical College, New York City.

Cortical changes in the egg cell on the approach of cell division can be demonstrated with the needle. In polar body formation the change appears to be due to the presence of the nucleus for, on removal of the nucleus to another region of the cell, a corresponding change in the cortex occurs. Preparatory to division the bulk of the cytoplasm undergoes temporary gelation and constriction takes place in the region where liquefaction sets in.

The resting nucleus is an optically homogeneous body in which a granular network is often produced on the slightest injury. It is fluid in consistency in egg cells and possibly in other cells. Formation of the nuclear spindle was studied in germ cells and in egg cells during polar body formation and segmentation. In no case could spindle fibers be demonstrated. The nuclear substance assumes a spindle shape under the influence of the centrospheres. Liquefaction of the cytoplasm in the equatorial region of the cell is accompanied by a constriction which shapes the nuclear spindle into a dumb bell during the ana-and telo-phases. As the daughter nuclei draw away from one another they are connected by a strand which is of a sufficient consistency to distort the nuclei if caught and pulled by the needle.

The prechromosomal filaments appear in the prophase out of the hyaline nuclear matrix through the precipitation of granules in more or less irregular masses closely investing long slender cylindrical strands of a gel like consistency. Many of the diplotene filaments figured in fixed material may posssibly be due to the collapse of these strands into ribbon like structures with an accumulation of the granules along the edges. Shortening of the prechromosomal filaments is ac-

companied by a fusion of the granules thus forming the definite hyaline, viscous and comparatively rigid chromosomes. The chromosomes are imbedded in the nuclear spindle mass and undergo movements resembling those in drops which are undergoing changes in surface tension. The constriction of the nuclear spindle at its middle possibly aids the migration of the chromosomes by pushing them to the poles.

Many if not all of the structures which appear during cell and nuclear division may be explained as reactions in a mixture of colloidal materials producing local liquefactions together with precipitations and gelatins which may be made to disappear on changing the reaction.

16. A study of the reaction of lymphatic endothelium and of leucocytes in the tad-pole's tail toward injected fat. ELIOT R. CLARK and ELEANOR LINTON CLARK, Department of Anatomy, University of Missouri.

The present investigation is part of a series undertaken in order to study the growth and reactive powers of living tissues and cells, in the tad-pole's tail, by observing their response toward various injected substances. One of the authors has reported the results obtained by injecting small globules of paraffin oil. He showed that these globules were not absorbed and that, aside from a transitory leucocytosis, the various tissues and cells showed no reaction to the injected paraffin oil. In the present study, small amounts of various fatty substances were introduced subcutaneously, with the especial object of studying the reaction of the lymphatic capillaries. The substances injected were olive oil, oleic acid, cream and yolk of egg.

1. Olive oil. The oil was injected in the form of single globules, measuring about 50 μ in diameter. The globules diminished in size during the period of observation but were not completely absorbed after nineteen days. Soon after the injection, clear leucocytes were seen to pass through the walls of nearby blood-vessels and to approach the oil. Here they flattened out and formed a ring of leucocytes around the periphery of the globule. Soon after coming in contact with the oil, they became pigmented and were seen to contain small drops of oil. The lymphatic capillaries were evidently attracted by the presence of the olive oil; they grew toward it, even bending out of their course in some instances. Upon reaching the globule, the lymphatic tip remained in close contact with the rim of pigmented leucocytes for several days. In some cases, the tip of the lymphatic later extended beyond the oil globule. No pigmented leucocytes were seen to enter a lymphatic capillary.

2. Oleic acid. Immediately after injection, the oleic acid changed from a clear refractile globule to an opaque granular mass which was brown by transmitted and white by reflected light and resembled closely the sodium soap of oleic acid. The leucocytes responded to this substance more quickly and in larger numbers than in the case of the olive oil. They formed a ring around the injected mass several layers deep and all became deeply pigmented. On the day following the

injection, many small refractile droplets could be seen, scattered through the brown substance. The absorption proceeded more quickly than in the case of the olive oil but was not complete after ten days. The lymphatics responded, as in the case of the olive oil, by growing toward the injected substance. Pigmented leucocytes were observed to move away from the injected mass and to come into close contact with the tip or wall of nearby lymphatic capillaries. After remaining for five or ten minutes in close proximity to the lymphatic, they moved away again and, shortly before or at the time of wandering away, these leucocytes lost their pigment and became clear.

3. Cream and yolk of egg. Both of these substances consist mainly of an emulsion of very small droplets. The leucocytes were attracted to the injected cream or yolk in large numbers and actively took up the minute drops of fat. The leucocytes containing fat were then seen to wander off and to come into close relationship with nearby lymphatic capillaries. After remaining close to the lymphatic for a few moments, they became clear again. At the end of twelve hours, most of the injected droplets had been taken up by leucocytes, and after twenty-four hours all had been. On the second day, only a few pigmented leucocytes marked the site of injection. In spite of the rapidity of the absorption in the case of the yolk and cream injections, a definite growth of lymphatic capillaries toward the injected region was observed in some instances:

Conclusions. *a.* Lymphatics reacted to the injected fat by sending out sprouts which grew toward it.

b. Leucocytes responded quickly to the injected substances, migrated toward them in large numbers and actively engulfed the fat.

c. The fat appeared to be absorbed through the combined efforts of leucocytes and lymphatics.

d. Mesenchyme cells and blood-vessels did not respond to the injected fat.

e. The rapidity of the absorption depended upon the size of the fat droplets: the fine emulsions of cream and yolk were taken up very much more quickly than the single relatively large globules of olive oil and oleic acid.

f. The fat appeared to be changed within the leucocytes and to be absorbed in a soluble form by the lymphatics.

17. Some points on the urogenital system of myxinoids. J. L. Conel (introduced by H. D. Senior), University and Bellevue Hospital Medical College.

A study of the adult structure of the urogenital systems of Myxine and Bdellostoma. The work was done in the Zoölogical laboratories of the University of Illinois.

A central duct is present in the pronephros of both Bdellostoma and Myxine, but it is in a state of degeneration in both animals. This degeneration is more advanced in Myxine than in Bdellostoma, and includes the inner ends of the pronephric tubules and all parts of some of the largest tubules.

The Malpighian body of the pronephros in both Bdellostoma and Myxine is located at the posterior end of the pronephros, and in appearance and structure closely resembles the Malpighian bodies of the mesenephros. It is formed by the fusion of two or more glomeruli.

The glomerulus of the pronephros in young Myxinoids is exposed to the pericardial cavity through a large opening, thus resembling a glomus. This opening becomes constricted to a small tubule in adult animals.

The tubules of the mesonephric Malpighian bodies in Bdellostoma are structurally of two types.

Neither Bdellostoma nor Myxine is a protandric hermaphrodite.

**18. On the lipoidal nature of structures in the corpus luteum cells of swine.*

GEORGE W. CORNER, Hearst Anatomical Laboratory, University of California.

In a previous paper (The Corpus Luteum of Pregnancy as it is in Swine, Carnegie Institution of Washington, Contributed to Embryology, 5) the author called attention to certain structures appearing in the lutein cells of swine after fixation in formol, in the form of small hollow spheres lying in spaces in the outer part of the cytoplasm. They are probably similar to bodies found in the lutein cells of rabbits by Franz Cohn (Arch. f. Mikr. Anat., 62, 1903). In sows they occur only during the first half of pregnancy, and the changes leading to their disappearance from the cells are so characteristic that by examining the corpus luteum it is possible to estimate the stage of the pregnancy with some accuracy.

It was tentatively suggested, in the former paper, that these bodies represent an elaborate modification of the Golgi-Holmgren intracellular canalicular apparatus. However, preparations since made, by Cajal's uranium nitrate technique, show the above described structures and the Golgi net to be present in the same cell and independent of each other. It has been found that they are not present in the fresh tissue, appearing only after several hours in formol, Zenker's fluid, or other aqueous fixatives. They are stained blue by Nile-blue sulphate, pale brick-red by neutral red, give a brown lake with Weigert's hematoxylin, stain positively with Ciaccio's method, and are not anisotropic when seen under the polariscope. They do not stain with Nile-blue after treatment with alcohol of 65 per cent or stronger, and stain but faintly or not at all after a day's immersion in acetone, chloroform, ether, xylol, and benzene. It seems clear, therefore, that the appearance of the spherules is produced by the swelling into rounded masses, in the presence of water, of a lipoid, which is present in the luteum cells and which is probably a phosphatid, to judge from its microchemical reactions. Apparently, however, in the process of swelling of the lipoid material some proteid is carried with it, and is precipitated in the spherules during fixation, for even after removal of the lipoid substance by alcohol, the skeletons of the spheres remain, and may be stained by appropriate dyes, especially Mallory's con-

nective tissue stain. The hollow center in such stained preparations is due to the fact that the spherules usually form about the globules of neutral fat which the lutein cells of early pregnancy contain in great numbers, and the spaces about them are due to shrinkage of the cytoplasm.

The discovery that the appearance of these bodies after fixation is due to an artefact does not detract from their interest, since they enable us to detect the presence of a constituent of the cell which may be of importance in the economy of the corpus luteum, and to follow histologically the changes in amount of this substance.

**19. Oestrus and ovulation in swine.* George W. Corner and A. E. Amsbaugh, Hearst Anatomical Laboratory, University of California.

In order to obtain a point of departure for studies on the changes of the uterus and ovaries during the reproductive cycle in swine, we have undertaken to determine what relation exists between oestrus and ovulation. Breeders agree that oestrus occurs every eighteen to twenty-one days, usually lasting three days. (One of our animals showed signs of heat on four successive days.) Heat is not terminated by copulation, which may occur repeatedly. We have found that animals killed during this period usually show recently ruptured Graafian follicles, and in such animals we have been able to recover the ova by washing out the Fallopian tubes. Rupture of the follicle is spontaneous, occurring even in the absence of the boar. In one animal in which oestrus was noted sixteen hours before killing, copulation almost certainly having occurred during the interval, rupture of the follicles had not yet taken place, although sections showed an intact follicular wall with a normal ovum in which the first polar body was forming. It is clear, therefore, that ovulation occurs during oestrus, and probably on the first or second day of the period, since we find regularly that ovulation has taken place when sows are killed on the third day of oestrus.

The unfertilized ripe ovum of the sow, as found in the tube, measures 155 to 165 μ in diameter. The zona pellucida is 7 to 8 μ thick, enclosing a yolk heavily laden with fat globules, obscuring the nucleus. The polar bodies are often clearly seen in the fresh ovum. Study of a small series of ova which have been cut into serial sections seems to show no deviation from the stages reported in other mammals; the first polar body is formed within the follicle just before rupture, the second in the tube. Entrance of the spermatozoön and fusion of the pronuclei occurs in the tube.

20. Potentialities of the lymphoid hemoblasts of the adult spleen. (With demonstrations.) Vera Danchakoff, College of Physicians and Surgeons, Columbia University.

The adult spleen is a lymphopoietic organ. Under normal conditions numerous small lymphocytes are developed in its follicles. The stem cells of the small lymphocytes are morphologically similar to the stem

cells of other blood cells, either granuloblasts or erythroblasts. The morphological structure of all these stem cells or lymphoid hemoblasts is permanently retained by the organism from the time of the first appearance of blood.

Embryogenetic studies have shown that the various differentiations of the hemoblasts is associated with different environmental conditions. A hemoblast under definite environmental conditions can split off only one kind of blood cells. What is the action exerted by the environmental conditions on the hemoblasts? Do they alter the metabolism of the hemoblast irreversibly, definitively narrowing its potencies to the limits of its prospective value, or do they merely condition its differentiation for the time in which they act, temporarily inhibiting some of its potencies, which may subsequently become active in other environments?

If the normal differentiation into a small lymphocyte is forced upon a hemoblast in the follicle of the spleen by definite environmental conditions, other potentialities should be realized by the same cell under other environmental conditions.

A mesenchymal cell in the allantois responds to a stimulus or to an irritation in a characteristic manner, it readily proliferates; if situated in a well vascularized region, it rounds up, becomes mobile, transforms into a hemoblast; finding itself outside of the vessels it differentiates into a granuloblast and finally into a granular leucocyte. The stem cells in the lymphoid follicle of an adult spleen do not differentiate under normal conditions into granular leucocytes. Would this differentiation take place if the follicle of an adult spleen were transplanted into environmental conditions, favorable to the granuloblastic differentiation? If the potencies of the stem cell in the follicle of an adult spleen, besides its own prospective value, include the prospective values of the stem cells of granuloblastic tissue, then such differentiation of necessity must occur.

Cultures of spleen tissue of different animals were made on the allantois of the chick embryo. The cultures grew well and formed tumors of nearly 1 centim in diameter. Both embryonic tissue of the allantois and adult tissue of the spleen participated in the formation of the tumor. In many cases the tumors in well advanced stages consisted of a uniform granuloblastic tissue more or less richly vascularized, in which no distinction between adult and embryonic tissues could be drawn. The study of early and intermediate stages gives, however, precise information concerning the respective rôle, assigned to each tissue in the formation of the tumor.

The lymph follicle of the adult spleen is easily recognized by its arterial vessels and by the presence of small lymphocytes, which are lacking in the allantois of the embryo. Usually follicles, which in the cultures are immediately adjacent to the allantois persist and thrive. Several types of cells constituting the follicle react in definite and differing ways. The fate of the following cells of the spleen follicle in the culture could be determined:

1. Small lymphocytes. 2. Cells forming the reticulum. 3. Stem cells of the small lymphocytes.

Numerous small lymphocytes emigrate out of a follicle into the loose tissue of the allantois. Some of them remain in the follicle. They do not show here any signs of activity but remain inert. Very rarely can a mitotic figure in a small lymphocyte be recognized. The small lymphocytes gradually die out and are ingested by adjacent cells; in their cytoplasm remnants of ingested small lymphocytes may be discovered a long time afterwards.

Phenomena of a substantially different order are observed in the two other characteristic structures of the lymph follicle, in the hemoblasts and in the cells forming the reticulum. They are of a progressive order and reveal in these cells a high power of activity. Transplanted into a loose embryonic mesenchymal tissue the lymph follicle loses gradually its dense appearance; numerous cells of the reticulum hypertrophy, become free and together with the existing stem cells of the lymph follicle form large groups of amoeboid cells. The structure of these cells correspond in all details to that of the numerous hemoblasts which simultaneously develop at the expense of the embryonic mesenchymal cells in the allantois around the culture of the spleen.

If left in undisturbed relations with its normal environment the lymphoid hemoblasts of the adult spleen would naturally develop into small lymphocytes. But now when subjected to conditions, in which an embryonic lymphoid hemoblast displays an intensive granuloblastic differentiation, the lymphoid hemoblasts of the adult spleen follow exactly the same lines of differentiation, they become granulocytoblasts. New environmental conditions disclose in the lymphoid hemoblast of the adult spleen a potency to differentiation which was inhibited by its previous environmental conditions. The lymphoid hemoblasts of the adult spleen (and this applies as well to the mesenchymal cells of the reticulum) are morphological units, the development of which into small lymphocytes under normal conditions is but the realization of one possibility out of its larger range of potentialities.

21. Differential factors of erythro-granulopoiesis in the embryo of mammals and sauropsids. (With demonstration of hemotopoiesis in the yolk sac of birds.) Vera Danchakoff and Clayton Sharp, From the Anatomical Laboratory of Columbia University.

The development of the hemotopoietic function in the mesenchyme seems to be closely connected with the development of vascular channels in more than one respect.

The first appearance of blood corpuscles is inseparably connected with the first development of vessels. Even the endothelial wall seems to become in Sauropsids, a differentiating factor in the development of the common mother cell. Again, the presence of a large sinus like venous capillary net favors highly a hematopoietic differentiation

in the mesenchyme. The effect upon the stem cells of separation by an endothelial wall, the influence exercised by the intravascular conditions within a sinus like net are factors, which determine, together with the cell complex of the cell its further differentiation. A comparative study of the development of the first hemotopoietic organs in mammals and Sauropsids is of interest when connected with the study of its determining factors.

The first striking difference in the hemotopoiesis of these two classes of animals is the difference in localization of hemotopoiesis during a great part of their embryonic life. In mammals hemotopoiesis is localized in the liver, while in Sauropsids, it is localized in the appendages of the yolk sac. If hemotopoiesis is an activity of the mesenchyme, induced by a definite complex of environmental conditions, there must be found a striking analogy between conditions encountered in the liver of mammals and those prevailing in the appendages of the yolk sac.

It is of course easy to understand, that hemotopoiesis cannot take place in the walls of the mammalian yolk sac, for there is not space in this region for a hemotopoietic organ to develop. Why, however, is this process transferred to the liver? May the circumstance of its entodermal origin constitute a factor in the determination of this organ as a hemotopoietic center? It does not seem probable, for the definite organ of erythro-granulopoiesis associates with the bone marrow, which is not an entodermal derivative.

It has been pointed out, that the large quantity of food material, present in the yolk sac, is one of the chief factors in determining the development of erythro-granulopoiesis in this region. Is this requirement fulfilled in the mammalian liver? It is, for the umbilical veins, carrying the resorbed food from the placenta, traverses the liver. The presence of this large quantity of food can be effective, only if the blood carrying it flows slowly through large channels. Such conditions are found in the hemotopoietic organ of the birds. These conditions repeat themselves in the liver of the mammalian embryo, when the developing liver converts the lumen of the umbilical veins into sinusoids. The existence of conditions favoring the absorption of definite substances from the blood stream, seems so important, that hemotopoiesis does not occur where these conditions are absent, e.g., in the placenta whose vessels are merely thoroughfares for the blood.

If the mere opportunity for resorption, the presence of food material and favorable conditions, was sufficient for the development of hemotopoiesis, mesenchyme in the liver of Sauropsids would be induced to undergo a hemotopoietic differentiation, as it has in the liver of mammals; for the omphalo-mesenteric veins in birds carry large quantities of food material from the yolk sac and are transformed also by the growing liver into sinusoids. But, the mesenchyme of the bird liver does not develop a hemotopoietic function.

There must be an essential difference between substances carried by the blood of the umbilical veins in the mammalian embryo and those

carried by the blood coming through the omphalo-mesenteric veins of the Sauropsids. Though both are rich in food necessary for embryonic development, the blood of the omphalo-mesenteric veins of the Sauropsids has passed through a venous plexus, in the appendages of the yolk sac, which are engorged by multiplying and differentiating blood cells. These cells are the first to profit and to abstract from the resorbed food certain substances necessary for their multiplication and specific hemotopoietic differentiation.

The blood reaching the liver in the Sauropsids, therefore, has been filtered of definite substances necessary to the mesenchyme for its differentiation into erythro-leucopoietic tissue. The mesenchyme of the liver in Sauropsids, though surrounded by sinusoids, in which the resorption of food material may easily occur fails of specific development because of the lack of specific substances in this food material.

22. Further verification of functional size changes in nerve cell bodies by the use of the polar planimeter. (Lantern.) DAVID H. DOLLEY, Laboratory of Pathology, University of Missouri.

Kocher (Jour. Comp. Neur., vol. 26, 1916, 341) severely attacks the work of the writer on the basis of area measurements of nerve cells from undisturbed and exercised animals by means of the polar planimeter.

I have tested the planimeter method, not by averaging all cells measured from any region irrespective of their functional stage, as Kocher did, but by applying it to the same number of cells from every functional stage. Data of average diameter measurement were obtained concurrently from all series, and the two methods compared graphically. The two methods afford results absolutely identical in every detail both in size and nucleus-plasma relations, thereby verifying previous findings. The area method has no special or superior value in the case of uniformly shaped cells, though it would be well to use both methods in the case of irregular contours. Though exact in itself, the planimeter gives only two dimensions, with smaller variations than in volume calculations, and hence may be quantitatively misleading.

Kocher finds only slight variations in area size between control and exercised animals. The essential fallacy in denying any functional size differences from the results of comparative measurements when all stages are averaged together depends upon the tendency to a general uniformity of absolute size of corresponding nerve cells among animals of the same species. Further, when the third dimension is ignored, and Kocher's only reference thereto is in the heading of a table "volume expressed as square inches," it follows that there is less range of variation between functioning type sizes than if volumes were used, and the averaging tends better to equalize differences due to unequal distribution of various-sized types. Kocher's results are just what might be expected, and instead of confounding the writer in respect to functional size changes, tend only to support his induction of a uniformity of size relations as a general rule for a species.

Kocher confirms the existence of all the stages interpreted as functional by the writer. However, he admits no significance to them, because he finds them all in undisturbed as well as exercised animals. His conclusion from this of absence of qualitative differences is not, as he ignorantly thinks, destructive to me, but is the first induction I should wish to be confirmed since it throws nerve cell function solely on the fundamental quantitative principle.

He denies such quantitative differences in comparative differential counts, but since for one thing certain stages as diagnosed do not accord with his text statements and are unlikely upon the basis of relative differentiation, these counts need not be taken seriously.

Kocher's sweeping criticism falls into absurdity, being based on objective results in the above respects confirmatory of my own conclusions.

23. 'Histiocytes' and 'macrophages' and their relations to the cells of normal blood in animals stained intra vitam with acid colloidal dyes. Hal Downey, Department of Animal Biology, University of Minnesota.

Various colloidal substances, such as aqueous suspensions of lithium carmine, of the azo dyes Pyrrolblau, Trypanblau, etc., of collargol, India ink, and of various other non-toxic colloidal substances injected into the veins of animals are taken up very rapidly and stored in the form of granules by certain cells of the hemotopoietic organs, liver, and of the loose connective tissue. Repeated injections of the same animal result in an increase in the number of 'dye granules' in the cells, and also in the number of cells which contain the dye. Cells containing the dye granules have been termed 'histiocytes' by Aschoff-Kiyono, 'pyrrol cells' by Goldman, 'macrophages' by Evans.

Schulemann ('12) believed that the dye granules represent a combination of dye with a reaction body of the cell, and also that various preformed structures, such as plasmosomes, secretory granules, etc., can be made visible by means of these dyes. V. Möllendorf, Pappenheim and Tschaschin also agree with this earlier view of Schulemann. At present Schulemann and Evans believe that the dye granules are merely concentrations of the colloidal suspensions which are located within cytoplasmic vacuoles. They are not combined with any constitutents of the cell. The formation of dye granules is therefore a physical process and not a chemical union of preformed structures or receptors of the cell with the dye. In his latest paper Schulemann ('16) claims to have demonstrated the physical nature of the granules experimentally. If the results of these experiments are correct then we must agree with Evans that the fine particles of the injected suspensions are phagocytosed by the cells which are able to store the dye in the form of coarse granules. Phagocytosis, therefore, is the process which quickly cleans out the particles of the injected suspensions from the fluids of the body, and cells which phagocytose the suspended particles should obey the general laws of phagocytosis.

The cells of the circulating blood do not take up these substances. even though the latter are injected directly into the blood stream, However, histiocytes appear in the blood stream after repeated injections of the colloidal substances when the animal becomes 'overloaded,' and Aschoff-Kiyono have demonstrated them in sections of the veins of the hematopoietic organs after a single injection of lithium carmine. They do not take up the colloidal substance directly from the circulation, but become loaded with it while in the tissues, especially of the hematopoietic organs. They are never abundant in the general circulation but may be quite numerous in the veins of the liver and hematopoietic organs. The fact that Aschoff-Kiyono must resort to sections in order to demonstrate the presence of the histiocytes seems to favor the view of Mitamura and Masanori that the anesthetic, or the manipulation during the operation, or premortal agony cause the separation of endothelial histiocytes from the hematopoietic organs and their entrance into the blood stream. These authors find the histiocytes to be very rare in the veins of living animals, but quite numerous in dead animals. These facts seem to indicate that the passage of histiocytes into the blood is more or less accidental, a view which is further strengthened by the observation of Aschoff-Kiyono that they are rapidly filtered out of the circulation by the capillaries of the lung. This latter fact shows that the dye cells act as foreign bodies when they reach the blood stream, and it also accounts for the small numbers of histiocytes in the general circulation.

The few dye cells which get into the circulation in overloaded animals, and the free histiocytes of the serous cavities, tâches laiteuses, and many of those of the loose connective tissue are identical morphologically with the larger lymphocytes and large mononuclears of the normal blood, excepting that they contain the dye granules while the latter do not. For this reason, and because of the fact that the reticular cells, especially those lining the sinuses, and their free derivatives in the hematopoietic organs, the stellate cells of the sinusoids of the liver, and the clasmatocytes or resting wandering cells of the loose connective tissue are the cells which show the greatest preference for the dyes, it has been claimed by Goldmann, Aschoff-Kiyono, Pappenheim, Schulemann-Evans that the dye cells are always of tissue origin. In other words, true blood cells will not take up the dyes, and we therefore have a sure method for distinguishing between blood cells and tissue cells. The free wandering cells in the loose connective tissue which take up the dyes, and those about the tâches laiteuses of the omentum and in the serous cavities are tissue cells although they are identical in structure with the lymphoid cells which we see in the circulating blood of normal animals.

The above authors, excepting Pappenheim, also claim that the histoicytes, both fixed and free, are closely related cells which constitute an independent cell-line which is absolutely distinct in origin and function from anything found in the circulation of normal animals.

The only worker in this field to seriously oppose the idea of the independence of the histiocytes is Tschaschin, who believes that in experimental inflammation of the loose connective tissue in vitally stained animals lymphocytes leave the vessels in great numbers and increase rapidly in size to form 'polyblasts' which take up the dye and store it in the form of the typical dye granules of the histiocytes.

The results of the following simple experiments are opposed to the theory of the independence and close relationship of all the dye cells. They also show that blood cells under proper conditions will take up the dyes as rapidly as do the so-called histiocytes.

Rabbits and albino rats were the experimental animals, and Pyrrolblau, one of the acid azo dyes, was used as the colloidal suspension.

Intramuscular injection of a 1 per cent suspension of the dye in water caused immediate migration of polymorphonuclear leucocytes to the site of injection. More polymorphonuclears were obtained if a suspension of aleuronat was injected first. When the animals were killed twenty-four hours after the injection sections of the muscle showed that the polymorphonuclears were gorged with the dye which was stored in the form of coarse granules identical with those of the histiocytes of animals stained intra vitam by intravenous injections of the dye. None of the leucocytes of the circulation contained the dye granules.

The most convincing results were obtained when the dye was injected directly into a segment of the femoral vein which had been isolated from the general circulation by a double ligature. The vein was tied off first and then the dye injected into the vessel between the ligatures. Twenty-four hours later the ligatured portion of the vein was removed, fixed and sectioned. It contained great numbers of polymorphonuclear leucocytes which were loaded with the typical dye granules. All of the larger lymphocytes and large mononuclears present also contained the dye granules, the latter cells being identical in structure with the free histiocytes of the peritoneal cavity of animals stained intra vitam by peritoneal injections of the dye. The presence of the dye in the ligatured vessel has attracted great numbers of polymorphonuclears from the vessels of the surrounding tissue or from the vasa vasorum, but it seems to have had no influence on lymphoid cells other than those which were already contained in the ligatured vessel. The lymphoid cells are not more numerous than would be expected in the amount of blood contained in the vessel.

The fact that polymorphonuclear leucocytes have wandered into the vessel does not destroy the value of the experiment, the most significant feature of which is the storage of dye in the form of typical dye granules by cells that are primarily blood cells, and which under ordinary circumstances do not take up the injected dyes. The lymphoid cells containing dye granules are those which were already present in the vessel, and therefore they are also blood cells.

These results seem to indicate that the reaction of cells to colloidal suspensions is not sufficiently specific to be used as an index of cell-lineage. Mechanical conditions and nature of the surrounding medium

undoubtedly play an important rôle in these reactions. In the blood stream the cells hardly get a chance to phagocytose the particles of the injected colloidal suspensions, for the latter leave the circulation almost as soon as they are injected. The presence of dye granules in the reticular cells of the lymph nodes, especially in those lining the sinusus, within a few minutes after injection indicates that the suspensions pass very quickly into the lymph stream to be removed from the latter by the reticular cells.

That the reticulo-endothelial cells should show great voracity in the taking up of the dye is not at all surprising, for we know that they are among the most active phagocytes of the body. This is also true of the free cells which are cut off from the reticulum; they will phagocytose erythrocytes, bacteria or any other foreign substance about as readily as they do the injected dye.

The lymphocytes of the nodes do not take up the dye nor any other foreign substance, such as living bacteria, carmine, etc. This is because they are immature cells having relatively small amounts of cytoplasm. Tschaschin has shown that when they migrate into inflamed areas they rapidly develop into protoplasmic phagocytes which take up the dye, and the experiment with the ligatured vessel shows that the larger and more mature lymphocytes which are caught in isolated segments of the circulation, where they remain in contact with the dye for some time, will also take up the suspension. In the free circulation neither the lymphocytes nor the polymorphonuclear leucocytes take up the dye, probably because of the fact that the dye is eliminated from the circulation so quickly that the phagocytic cells are not in contact with it for sufficient length of time to be able to take it up. The mechanical agitation of the blood in the free circulation probably also has something to do with the prevention of phagocytosis.

That mechanical conditions are a factor in phagocytosis is indicated by the results of intravenous injection of ordinary carmine ground up in salt solution. The particles of this suspension are very much coarser than those of the colloids used. Hoffmann and Langerhans have shown that this substance remains in the circulation as late as 148 days after the injection, and that it does not enter the lymph nodes until 3 days after injection. Within the circulation the carmine is phagocytosed very freely by both the polymorphonuclears and the macrophages. It takes several days, however, before the last of the carmine particles are included in phagocytes (6 grams of carmine at one injection!). The entire reaction can be explained by the slow diffusibility of this substance; it is eliminated from the circulation very slowly, and the phagocytic cells of the blood have abundant opportunity to take it up.

The more diffusible colloids are also taken up by phagocytes, but isolation from the general circulation is necessary before phagocytosis can take place. A further illustration of this rule is to be found in the work of Kline and Winternitz on experimental pneumonia in animals stained intra vitam with Trypanblau. Polymorphonuclears contain-

ing typical dye granules were found in the alveoli, bronchioles and blood vessels of the involved lung but not in the general circulation. Injection of the blood vessels of the involved lung showed that they were cut off from the general circulation by plugs of fibrin in the capillaries. Pappenheim and Fukushi also reported dye granules in polymorphonuclears and in lymphoid cells of peritoneal exudations. Rosenthal has shown that even living organisms are rarely phagocytosed within the circulating blood. A virulent bacteria injected into the tail vein of mouse were phagocytosed by 'endothelial' cells, chiefly the stellate cells of the liver. Wandering cells of the blood became active only when the bacteria were so numerous that the 'endothelial' cells could no longer take care of them. Werigo found anthrax bacilli to disappear from the circulation within a few minutes. They were held by phagocytes in the spleen, liver and lungs.

The writer's experiments with Pyrrolblau have shown clearly that the type of phagocytic cells involved in the process of taking up the dyes depends altogether on the conditions of the experiment. According to Buxton and Torrey this is also true when living organisms are used. Typhoid bacilli and staphylococci injected into the peritoneal cavity appeared within the macrophages of the mediastinal lymph nodes within one hour. They conclude that the macrophages have seized the organisms because they were present before the arrival of the polymorphonuclears. Later the latter invaded the nodes in great numbers and seized whatever organisms were left.

The power to phagocytose may vary greatly in cells of the same type (Hektoen, Rosenow), and cells which are not ordinarily phagocytic may become so under certain conditions, as shown by Achard, Raymond and Foix, who reported a case in which the eosinophils of a pleural exudate were very active as phagocytes. Phagocytic eosinophil leucocytes have also been reported by Lattan-Larrier and Parvu, Wendenburg, and by Weinberg-Séguin.

It is evident that phagocytosis is a physiological process which is not confined to any one type of cell, and that the material to be phagocytosed which under ordinary conditions is taken up by a certain type of cell may, under slightly different conditions, be taken up by cells which genetically and structurally are quite distinct from the first type. The taking up of colloidal dyes seems to be, in many cases at least, very similar to phagocytosis as we have known it before the advent of the azo dyes. Dye granules have been reported in the following cells: reticular cells, endothelial cells, clasmatocytes, lymphocytes, polymorphonuclear leucocytes, hepatic cells, cells of the adrenal and epithelial bodies, interstitial cells of the testis, cells of the Graafian follicles, hypophysis, plexus chorioideus, ectoderm cells of the placenta and the giant cells of this organ. The granules of some of these cells may be vitally stained preformed structures. Nevertheless, it is evident that the reaction is not specific for any one line of cells, and all attempts to classify cells according to their reactions to these dyes must be regarded as failures, especially since Kiyono, one of the most

ardent defenders of the theory of the specificity of the reaction, is forced to admit that lymphocytes of lymph nodes in the later stages of aseptic inflammation may enlarge and develop relatively more protoplasm, when it is impossible to distinguish them from the true histiocytes of the organ, and impossible to show that they do not take up the dye.

24. A human embryo of seven to eight somites. H. M. Evans and G. W. Bartelmez, Department of Embryology, Carnegie Institution of Washington and Department of Anatomy, University of Chicago.

This embryo was obtained from an aborted ovum measuring 18.0 by 13.0 by 10.8 mm. including the villi, fixed intact in 10 per cent formalin. The age was estimated clinically as three weeks. The embryo measured 2 mm. in length in formol and belongs in the group with the Mall embryo no. 391 (described by Dandy), the seven somite Spee embryo, the 2.11 mm. embryo of Eternod and the R. Meyer embryo no. 335.

The embryo was found attached directly opposite the chorion laeve, projecting into the extraembryonic coelom at right angles to the chorionic wall, supported by a few strands of magma. The embryo lies flat upon the yolk sac, with head and tail folds rising above it. The height of the head fold may have been slightly increased by distortion in the fixative but this region could not possibly have been bent ventrally over the yolk sac as it is in the Keibel embryo of 6 somites (Normentafel no. 3), and the above mentioned Eternod specimen. The amniotic cavity is large and the amniotic duct extends along the belly stalk. In dorsal view the embryo appears somewhat like a spoon, the expanded cephalic neural folds corresponding to the bowl. The neural tube is closed from the middle of the hind brain to the level of the seventh somite. Caudally the neural folds gradually flatten out and pass over into the primitive streak at Henson's node. The neurenteric canal has already closed. It is possible to delimit forebrain, midbrain and three hind brain neuromeres since the cerebral flexure has just begun to appear, the neural crest is actively proliferating and the otic plate and ganglion are well defined. The asymmetric forebrain is bent almost at right angles to the hindbrain, the midbrain forming the knee. In the forebrain two shallow sulci can be distinguished converging rostrally: they are the earliest stage of the optic sulci yet described in man. The neural crest cells are migrating from the dorsolateral region of the folds in the midbrain and hind brain as far caudally as the VII-VIII ganglion. This is a bulbar swelling of the neural fold dorsally, lying opposite the thickened otic plate.

The pharynx is intermediate in development between that of 391 in the Mall collection and 335 of R. Meyer. Its epithelium is in contact with the ectoderm of the oral membrane, the first visceral pouch is well developed and its dorsal diverticulum touches the thickened ectoderm at one point. The second pouch is beginning to form and there is an asymmetric thyroid anlage. The hind gut extends but five sec-

tions caudal to the origin of the allantois and there is no cloacal membrane. The chorda begins near the upper end of the pharynx as a thickened ridge and is everywhere incorporated in the entoderm except in the region of Henson's node.

The heart is an almost bilaterally symmetrical tube formed by the union of the vitello-umbilical veins lying ventral to the pharynx. A pair of delicate vessels, the first aortic arches pass around in front of the first pair of visceral pouches from the bulbar end of the heart to the greatly dilated cephalic ends of the dorsal aortae. The latter have four well developed pairs of dorsal rami, the first two of which are growing in the direction of the fifth and eighth ganglia respectively. Caudally the aortae break up into a plexus on the dorsal wall of the yolk sac which plexus in turn gives rise to the umbilical arteries at the beginning of the belly stalk. More rostrally the vitelline vein is beginning to differentiate from the plexus on the yolk sac.

A comparison of the various embryos of this stage shows that the different systems of organs do not develop pari passu and it is impossible to arrange them correctly in a series by referring to a single character such as number of somites or greatest length. In the present case the nervous system is relatively more differentiated than any other. It is necessary to seriate a limited group of embryos separately for each organ system.

**25. Endothelium and wandering connective tissue cells as seat of origin of hemoglobin.* J. H. Globus, Cornell Medical School, New York City.

In the course of an investigation of the blood elements in a large number of invertebrates, the writer selected three species of annelides as best adapted for the study of the origin of hemoglobin. The intimate relationship of this respiratory pigment with erythrocytes had lead many investigators to believe that the solution of the problem of the origin and differentiation of red blood corpuscles would also uncover the ultimate source of origin of hemoglobin. This, perhaps, holds true of vertebrate blood, but in invertebrates and, especially, in annelides it is possible to find species with hemoglobin circulating free in the blood plasma. Here the way is open to trace the respiratory pigment to the group of cells, tissue or organ responsible for its formation.

The three annelides studied show wide variations in the organization of their vascular system, while they retain great similarity in the rest of their internal structures. Arenicula Cristata a marine annelide, has a very highly developed vascular system, with pulsating heart, numerous large and small blood vessels, forming a net-work about the gut and sending in branches into the body wall. Diopatra dibrahchiata, another marine annelide, shows a less complex vascular system, the vessels being arranged mainly about the gut and forming by their smaller branches a plexus. In Rhyncobolus, on the other hand, we find only a rudimentary ventral vessel, the blood fluid occilating in the hæmocoele.

In Arenicula one finds in the intermuscular connective tissue, a large number of giant cells loaded with brownish rounded pigment granules. These cells when fixed are found to be arrested in various irregular forms, indicating amoeboid movements. Their progress seemed to be in the direction of blood vessels. These blood vessels are surrounded by similar large pigment cells which seem to form their limiting wall, as no other tissue, fibrous or muscular is there discernible. Some of these cells are arrested by the killing fluid in the process of emptying their granular contents into the lumen of the blood vessel. Their granules when stained with iron-detecting reagents indicate a rich iron content. They also react readily to Eosin and other acid dyes in a way similar to the hemoglobin containing plasma and erythrocytes in vertebrates. Other staining reactions indicate that (in some stages) these granules are modified nuclear derivatives. In some cells there are discernible three types of granules showing a transition from a nuclear to a plasma reaction, with the indifferent stage of brownish granules intervening. Thus, it is reasonable to believe that these cells are concerned with the manufacture of the respiratory pigment.

Similar conditions exist in Diopatra, with the only difference that the wandering mesenchymal cells are not as numerous, and that the endothelial cells are not as large.

It is interesting to note that while in the above two species which have rather highly developed vascular channels, the hemoglobin is held in solution in the plasma, and can be traced to the cells lining the walls of the blood vessels in Rhyncobolus we have only a rudimentary vessel, and here the hemoglobin is incorporated in nucleated red blood corpuscles. Thus the origin of hemoglobin in this species is obscured and its development must be worked out along the lines of origin of the hematids. There is, however, sufficient ground to believe that these hematids are derived from the mesodermal layer of the wall of the gut.

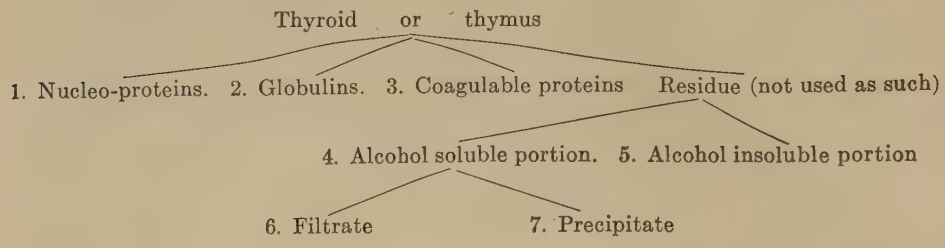
26. Studies on internal secretion IV. Treatment of tadpoles with thyroid and thymus extracts. J. F. GUDERNATSCH, Department of Anatomy, Cornell University Medical College, New York City.

In some previous experiments on growth and differentiation portion of fresh thyroid, thymus and other glands were given as food to developing tadpoles. At the same time the animals lived in aqueous extracts of the entire glands, some of the tissue juices, of course, going into solution. In the experiments reported here an attempt was made to study the influence upon the development of tad-poles of several distinct constituents of the thyroid and thymus. By a detailed chemical procedure each organ was split into seven products, all in aqueous solutions.[1]

[1] The solutions were prepared by the Department of Experimental Medicine.

Six of these portions contained each one 'agent,' the seventh, termed the alcohol soluble portion, combined two 'agents,' precipitate and filtrate, before the process of precipitation.

The seven isolated portions were:



The nitrogen content of the solutions was determined and the same concentration used for each set of tadpoles. An ordinary meat and vegetal diet was given.

The thyroid and several of its constituents proved the most powerful stimulants for accelerated differentiation, while growth was suppressed almost entirely. When graded according to their action on differentiation the thyroid portions give the following list:

(Thyroid, entire gland, dessicated; Parke, Davis and Company)
Thyroid nucleo-proteins.....no growth
Thyroid globulins
Thyroid acohol insoluble portion
Thyroid coagulable proteins
Thyroid alcohol soluble portion
Thyroid filtrate
Thyroid precipitate.....greatest growth
Control

The last three products hardly showed any effect on differentiation, the tadpoles treated with the precipitate running almost parallel to the control. Tadpoles treated with the first four portions, however, metamorphosed from five to six weeks before the control, while they never reached the size of the control animals. Nucleo-proteins and globulins checked growth entirely.

Three sets of the experiment started at different ages of the tadpoles —each interval being about four weeks—showed strikingly that older animals react to the thyroid treatment faster than younger, being, of course, nearer the stage of metamorphosis. In the youngest set the nucleo-proteins required twenty days to bring about metamorphosis, in the next set six days and in the oldest four days.

It has been claimed that the amount of iodine present in the thyroid is mainly responsible for its action. It might be possible to determine this question by using the several thyroid products in the same iodine concentration. In the present experiment they were equalized as to

their nitrogen content. Graded in regard to the iodine present they range as follows:

Nucleo-proteins
Coagulable proteins and alcohol soluble portion
Globulins
Alcohol insoluble portion
Filtrate
Precipitate

This column does not run parallel with the previous one, although the nucleo-proteins and the precipitate occupy the corresponding places.

Considering the action of the thymus as a whole, viz., retardation of differentiation, these experiments furnished some bewildering results. Only two of the seven products of the thymus delayed differentiation considerably, the alcohol soluble portion and the precipitate. The rest brought about differentiation simultaneously with or ahead of the control. It is impossible at present to explain these facts. It becomes necessary to assume either that the thymus furnishes several products of different physiological properties or that five of the seven constituents of the fresh gland are inactive. The latter assumption does not seem plausible; for the mass of the nucleo-proteins alone, for instance, is far greater than the alcohol soluble portion.

Beginning with that thymus product most active in retardation a graded list of the seven constituents would read as follows:

Thymus precipitate
Thymus alcohol soluble portion.....slowest growth
(Thymus entire gland, dessicated; Parke, Davis and Company)
Thymus filtrate
Control
Thymus alcohol insoluble portion
Thymus globulins
Thymus nucleo-proteins.....fastest growth

The expectation that the corresponding constituents of the two glands would be most active in counteracting each other was not realized; for it will at once be seen that in general the serial arrangement of the thymus products is almost the opposite of that of the thyroid series.

It is impossible here to give all the growth curves. In the thyroid group the nucleo-proteins (strongest differentiator) permitted no growth, the filtrate and precipitate (weakest differentiators) allowed the tadpoles to grow to normal size in about the normal time. Thyroid filtrate and precipitate may well be considered inactive as far as differentiation is concerned. They may have other physiological properties not disclosed in these experiments. In fact, injection experiments on mammals revealed such properties, especially in the case of the filtrate. In the thymus group the nucleo-proteins gave most, the alcohol soluble portion least rapid growth. Both have their position at opposite ends of the above list showing their influence on differentiation.

**27. The effect of feeding Sudan III to albino rats.* S. HATAI, The Wistar Institute of Anatomy and Biology.

The primary object of feeding Sudan III was to determine whether the myelin sheaths could be stained as they were formed. This attempt failed entirely but the alterations noted in the growth of the body and organs suggested the desirability of further studying these responses. The following is a brief summary of the results so far obtained by the use of 135 rats, representing 19 litters.

1. The amount of Sudan III given was 0.008 grams per rat per day. The Sudan was mixed with 1.5 cc. of olive oil and given with the other food.

2. It has been found that rats less than 30 grams in weight do not grow at all when given the Sudan III in oil, while rats more than 30 grams but less than 50 grams in weight show an increase in weight for the first few days of feeding, but if the Sudan is continued they begin to emaciate. Rats which weigh more than 50 grams appear highly resistant to this dye and it takes several weeks of feeding before they show the effects seen in the younger animals. We find no noticeable injurious influence due to the oil, when given in the quantity here used.

3. When the effect of the Sudan III is marked, the thymus and sex glands show considerable diminution, while the liver and pancreas show noticeable increase in weight. In several cases the thymus gland had disappeared completely.

4. The percentage of water in the liver and brain diminished, while that in the lungs, pancreas and blood increased. An increase in the alcohol-ether extracts was found in the liver, brain and blood.

5. As determined by a color test, a trace of Sudan was recovered from the lungs, pancreas and kidneys, while more than a trace was found in the liver. Complete absence of the dye was noted in the brain, spleen and heart.

6. All the Sudan rats were in a state of profound anemia. In one case nearly 40 per cent reduction of erythrocytes was found.

7. The present investigation shows that retardation of growth by the feeding of Sudan III can not be explained as due to a simple starvation, owing to the reduced availability of the fat after staining, as Riddle concludes, as there is clear evidence of more extensive pathological alterations such as anemia, fatty liver, nephritic kidneys, etc.

Since Sudan III fails to enter and stain the myelin, it is highly probable that this substance is not obtained directly from the ingested food, but is very probably developed in situ.

28. The ganglionic crest and mesectoderm of the chick in relation to the closure of the neural tube. FRANCIS W. HEAGEY, Creighton Medical College, from the Department of Anatomy, Columbia University.

The ganglionic crest of the trunk has long been known to differ from the mode of formation of that of the head. Neumayer in the Crocodilian embryo, Schulte and Tilney in cat embryos have shown that the ganglia of the cranial nerves were wholly derived from the

neuraxis without the participation of the ectoderm so that the crest was not an element intermediate between the neural tube and the somatic ectoderm. In view of this it was suggested that in more cephalic portions of the neural tube where ganglia were not formed that the ganglionic element might form a permanent constituent of the wall of the brain. In an effort to see whether there was an equivalent mode of formation in the sauropsids and what part the mesectoderm plays in the formation of the ganglionic crest I incubated and sectioned forty chick embryos, exercising great care in the determination of the age of each embryo. Weigert's hemotoxylin was used for the staining of the sections.

There were several marked differences from the mammalian type of the ganglionic crest formation. The medullary plate unlike that of the cat, showed no place of sudden transition from the neural to the somatic portions, i.e., there was no sharp neuro-somatic junction. Whereas in the mammal the cranial nerve anlage appeared as derivatives of the neuraxis in the angle between somatic ectoderm and the neural tube before the closure of the latter; in the sauropsid there was no evidence of any similar outgrowth until after the closure of the neural tube and the separation of the latter from the ectoderm. In the formation of the neural tube the amount of the medullary plate which was assimilated by the neural tube in the head region varied considerably from embryo to embryo. As a consequence the area of the surfaces of the medullary folds opposed to form the neural tube varied and the resulting stem which connected the neural tube with the ectoderm was either long or short depending upon the above conditions. Then bilateral cleavage planes appeared which separated the neural tube from the ectoderm and in so doing divided the stem into two portions, one a group of cells connected with the ventral surface of the ectoderm and the other portion was connected with the dorsal fusion point of the neural tube; from the former the mesectoderm is derived exclusively. The mesectoderm was present only from six to nine somites and in the prequintal region exclusively. It had no connection with the neural tube or relation with the ganglionic crest. Its presence depended upon the amount of the medullary plate included in the neural tube and the level of the cleavage planes through the stem of the neural tube. The portion of the stem of the neural tube remaining attached to the dorsal fusion point of the neural tube assumed different shapes depending upon the region and the relations to the cranial nerve anlages. In the intervals between the cranial nerve anlages it was merely a wedge of cells inserted between the dorsal extremities of the neural tube. In the region of these nerve anlages it formed a prominent mound of cells from whose sides lateral processes were seen to project.

The cells of the dorsal fusion point of the neural tube are a part of a true ganglionic crest because of their position in the neural tube, their relation to the cranial nerve anlage and their intimate connection with

the lateral processes on the dorsum of the neural tube in the quintal and the acustico-facial regions.

Based on these facts it is reasonable to conclude that the ganglionic crest of the sauropsid like the mammalian form is inherent in the neural tube and, that the mesectoderm does not participate in the ganglionic crest or the cranial nerve anlage but contributes solely to the head mesenchyme.

29. Maturation and initiation of development in Cumingia. L. V. Heilbrunn, (introduced by A. C. Eycleshymer,) Department of Anatomy, University of Illinois, College of Medicine.

The egg of the mollusc Cumingia is immature when shed into the sea-water, and it remains immature unless it is fertilized. Soon after sperm entrance, the first polar body is given off, and this is the first step in the developmental process. Artificially, polar body formation can be induced in any one of three ways.

In the first place, if the surface tension of the vitelline membrane is markedly lowered, it rises from the egg and maturation follows. This effect is in general produced by all substances which markedly lower surface tension, irrespective of their chemical constitution. Although many such substances were tested, only one or two failed to produce maturation, and in these cases the egg was very evidently injured by the reagent.

Secondly, if the stiff vitelline membrane of the egg is caused to absorb water and swell, then maturation also occurs. Such a swelling effect is produced by certain salts, and by dilute acids and alkalies.

Finally, if the vitelline membrane is removed by shaking, or if it is ruptured by placing the eggs in diluted sea-water, the egg can be made to undergo maturation.

All three of these treatments have one effect in common. The stiff vitelline membrane which encloses the egg is replaced by a much more plastic film. Thus in the Cumingia egg, as in the sea-urchin egg,[1] development can only occur if the egg is freed from the constraint of a stiff vitelline membrane. Moreover, the same types of reagents produce membrane elevation and membrane swelling in both eggs. But in Cumingia, unlike Arbacia, it is a membrane swelling rather than a membrane elevation which is the normal process.

Of the two leading theories of initiation of development, neither could be applied to the Cumingia egg. No evidence could be found for increase of permeability. On the other hand, the maturation process takes place normally in concentrations of potassium cyanide two hundred times as great as those supposed to check oxidations.

Although polar body formation can readily be produced by the methods just described, in the great majority of cases, segmentation does not follow. As in the sea-urchin egg, a gelatinization or coagulation can be demonstrated to precede segmentation.

[1] Heilbrunn, '15, Biol. Bull., vol. 29, p. 149; v. especially p. 183.

Thus it is apparent that the theories advanced by the writer to explain the initiation of development in the sea-urchin egg, are directly applicable to the egg of Cumingia. The only essential difference between the eggs lies in the fact that in the Cumingia egg, cortical change stimulates to maturation, whereas in the sea-urchin egg the maturation process has already been completed before the egg is fertilized.

30. On thyroidectomy in amphibia. E. R. Hoskins and Margaret Morris, New York and Yale Universities. Experiments performed at the Yale Zoology Department. (Presented by Dr. Hoskins.)

With due care to technique it was possible to remove successfully, the anlage of the thyroid gland, from young growing larvae of R. sylvatica and Amblystoma. The stage best suited for this experiment is that just preceding the beginning of the circulation of the blood. At this time there is no danger of hemorrhage and the chances of regeneration of the removed gland are fewer than with younger larvae. Chlorotone in salt solution was used to produce anesthesia.

The experiments are to be repeated on an extensive scale the coming season, as many more data are needed for final conclusions. The following results were obtained from thyroidectomy in 40 R. sylvaticae and 50 Amblystomae checked against an equal number of control animals.

A few of the thyroidectomized frog larvae developed abnormally shaped external gills in some of which, no circulation was to be seen. This was evidently due to injury to the vascular system. One animal developed no external gills although it lived and grew through the period during which external gills normally persist. From time to time larvae were killed and fixed. A number of them, both control and experimental died and were lost.

The operated animals grew less rapidly than the controls. Only one control and one experimental animal survived the normal period of metamorphosis. Of these the control showed hind legs two months after the operation and the other had not developed legs four months after the operation. The operated larvae showed no marked tendency toward albinism.

Serial sections were made of eight experimental larvae. The operation was seen to have prevented development of the thyroid gland in all but one case. The hypophysis as compared with that of the controls showed no changes in size or structure to be attributed to loss of the thyroid gland.

Among the amblystomae none developed abnormal gills. The average growth rate of the experimental larvae was less than that of the controls, but of the fourteen which were alive, after three months, the largest had had the thyroid removed. In none of the thirteen operated animals that were sectioned was there any regeneration of the thyroid. There were no changes in the hypophysis nor in the pigmentation of the skin following the thyroidectomy.

**31. Preliminary remarks on a collection of eleven gorilla brains recently acquired by the Division of Physical Anthropology, U. S. National Museum.* (With demonstration of casts.) A. HRDLIČKA, Smithsonian Institution, United States National Museum.

Through fortunate circumstances the Division of Physical Anthropology, U. S. N. M., has recently acquired, from the Kameroons, a precious collection of 14 brains of anthropoid apes. Of these brains no less than 11 are those of gorillas, while 3 are chimpanzees; and of the gorilla brains, 5 are adult, the rest ranging from young to practically full grown. Of the chimpanzees, 1 is adult, 2 young.

The whole collection is in a remarkably good state of preservation, with the exception of two brains of the young, and offers unprecedented opportunities for study.

The form of the brains, the fissure pattern and the variations, are of much interest.

**32. The morphological basis for the dominant pulmonary asymmetry in the mammalia.* GEO. S. HUNTINGTON, Columbia University.

The development of an eparterial bronchus only on the right side, and the pulmonary asymmetry resulting therefrom, is prevalent in at least 95 per cent of the mammalian genera and species whose intrapulmonary architecture is known, and the etiological factors responsible for this condition have been much discussed.

The asymmetry has in a general sense been ascribed to the left-sided position of the heart and aorta in the mammalia and to the resulting curtailment of the left thoracic space available for pulmonary extension. The difference in the mechanics of the intrapulmonary circulation in the two lungs during the placental period, due to the retention of the dorsal terminal of the sixth left aortic arch as the Botallian duct, has also been cited as a possible cause contributory to asymmetrical pulmonary development. In the early ontogenetic stages the rotation of the stomach has also appeared as offering a bar to the caudal progress of the primitive left lung-tube.

Aeby ('80) considered the dominant asymmetrical bronchial type of the mammalia to be derived from an ancestral bilaterally symmetrical eparterial condition by the phylogenetically acquired reduction and subsequent complete elimination of the left eparterial component, the right eparterial bronchus alone persisting and producing the asymmetry. Aeby offered no morphological evidence in support of this assumption.

Such evidence was apparently supplied in 1896 by d'Hardiviller, who described in rabbit embryos of the thirteenth day a transient bronchial vesicle arising from the left stembronchus, in the same position and in the same relation to the pulmonary artery as the eparterial bronchial bud of the right side. This left eparterial bud appears at the beginning of the thirteenth day, develops into a distinct hollow epithelial vesicle, whose lumen connects by a narrow canal with that of the left stembronchus, and then retrogrades rapidly. By the end of the thir-

teenth day it is reduced to a solid epithelial button, having lost its lumen and the open communication with the stembronchus, to which it is now attached solely by a solid epithelial pedicle. By the fourteenth day it disappears entirely, leaving no trace of its ephemeral existence.

D'Hardiviller finds in this discovery the absolute ontogenetic proof establishing Aeby's hypothesis of an archeal bilateral symmetrical eparterial component of the bronchial tree, from which the dominant modern asymmetrical type, with the eparterial element confined to the right side, evolved through the phylogenetic loss of the left eparterial bronchus. The latter appears in the ontogeny for only a very short period as the temporary derivative from the left stembronchus above described.

D'Hardiviller does not mention the number of 13 day embryos in which he found this evanescent vesicle. The context of his publication implies, however, that it is of constant occurrence. No subsequent confirmation of d'Hardiviller's observation has been made.

In no embryos of the critical stages accessible to me, either of the rabbit, or of other mammalian forms (cat, rat), was there any trace of the structure in question.

On the other hand in a series of 70 adult rabbit lungs, which I examined by corrosion for the occurrence of bronchial variants, I found the cephalic pole of the left lung, normally supplied by the ascending branch of the first left ventral hyparterial bronchus, supplied in one individual by an atypical first side branch of the left stembronchus arising dorsal to the pulmonary artery and corresponding in position to the larger right eparterial bronchus.

Narath, in describing the bronchial variants in a series of 39 adult rabbits, has reported somewhat similar conditions in two individuals. The conclusion appears justified that, on the evidence at present available, d'Hardiviller's observation was made on one or more variant embryos which, if development had proceeded, would have yielded atypical adult individuals possessing the above described left bronchial variant, but that no warrant is given for the assumption that such embryonic variants have a phylogenetic significance in the interpretation of the normal intrapulmonary architectonics.

A detailed study of the topographical relations of the developing mammalian lung in the critical stages reveals clearly the reason for the prevalent right-sided eparterial development, and at the same time shows the possibility of the occasional sprouting of a homologous bud from the left stembronchus. The conditions, while strongly favoring the development of the eparterial component of the right bronchial tree, are all against a corresponding bronchial development on the left side. The possibility of such an occurrence exists, as shown by the comparatively rare variation of the left eparterial bronchus, both in the embryo and in adult individuals of mammalian forms with typically asymmetrical bronchial tree (Echidna, Choloepus, Lepus, Tragulus, Homo), and by the normal bilateral eparterial type found in cer-

tain limited mammalian groups (some aquatic Carnivores and Rodents; some Cetaceans; the Camelidae among Ungulates, and the genus Cebus among Primates; Elephas, Hyrax).

Rabbit embryos of 10 mm. and 11 mm. show in transverse section the ventral wall of the œsophagus with the two vagi as the background against which the tracheal bifurcation, the stembronchi and their primary buds are placed. The pulmonary arteries accede to the ventro-lateral circumference of the trachea, along which they at first descend fairly symmetrically on each side. In approaching the tracheal bifurcation two of the extra-pulmonary structures gradually change their position relative to each other and to the pulmonary tube. The left vagus, which here is larger than the right nerve and forms a massive cord, turns ventrad. This is the expression of the rotation of the fore-gut to the right through which the left side of the gastric enlargement becomes directed ventrad. At the same time the left pulmonary artery turns caudo-dorsad in obedience to the sinistral axial twist of the heart and of its arterial pedicle.

As the result of these two rotations in opposite directions of the fore-gut and of the heart, the left vagus and left pulmonary artery approach each other and are, at the level of the tracheal bifurcation and of the origin of the stembronchi, crowded closely together. The reverse obtains on the right side. The right pulmonary artery turns more and more ventrad in descending, while the right vagus moves dorsad. An arterio-neural interval is thus opened up on the right side toward which the lateral circumference of the right stembronchus faces directly and into which it sends the bronchial bud responsible for the unfolding of the right eparterial bronchus. The latter thus comes to be placed between the right vagus and the right side of the œsophagus dorsally and the right pulmonary artery ventrally. On the left side this arterio-neural portal for eparterial development has been blocked by the approximation of left vagus and left pulmonary artery, or definitely narrowed to such an extent that it no longer affords a favorable path for extension from the left stembronchus. The first side-branch of the latter is hence forced to pass in front of the artery and thus becomes the first ventral hyparterial bronchus of the left side. This supplies by means of its large ascending branch the cephalic pole of the left lung, the same area which on the right side receives the eparterial bronchus.

The narrow interval between left vagus and left pulmonary artery might occasionally suffice for the passage of a bud from the left stembronchus contributing the cephalic portion of the left lung. In such a case, the adult variants above mentioned and the embryonic left eparterial bronchial bud described by d'Hardiviller, on which they are based, would be found. The ascending branch from the first left ventral hyparterial bronchus, usually supplying this area, would then be correspondingly reduced.

It is significant to note in this connection that in the rabbit, in which form both the adult variations above mentioned and their embryonic

anlage have been found, the cephalo-ventral pulmonary extension, forming the upper pole of the left lung, is very markedly reduced compared with the right side. The impulse to send an eparterial bud from the left stembronchus through the narrow vago-arterial interval, in spite of the small available space, would be fostered in this form by the reduced area it would be called upon to serve.

I believe that the developmental conditions just outlined furnish the adequate explanation of the prevalent asymmetry of the mammalian bronchial tree. This asymmetry is primarily founded on the different opportunity for cephalo-ventral pulmonary expansion afforded usually to the right and the left lung respectively, in consequence of the cardiac and oesophageal rotation in opposite directions. The sinistral turn of the heart and its influence on the initial direction taken by the pulmonary arteries is probably dependent in the first instance on the development of the left-sided mammalian aorta and its association with the left Botallian duct. This cardiac turn directs the left pulmonary artery dorsad and favors the caudal extension of this vessel in the left mediastinal background. By contrast, on the right side, the cardiac rotation directs the pulmonary artery ventrad, unimpeded by the retention of a communication with the systemic arterial arches, and this forward thrust carries into the caudal extension of the vessel.

The enormous mechanical force exerted by the Botallian duct on the conformation of the adult arterial pattern and heart is strikingly demonstrated in human major arterial variation by the figure-of-eight twist of a *right* thoracic aorta with the left subclavian artery as its last primary branch, arising from the descending aorta via a retained left dorsal aortic arch, with a left ductus arteriosus in place of a right, as should occur in right aortic arch development.

This cardiac rotation, which imparts the initial direction to the further growth caudad of the pulmonary arteries, is met, in its influence on pulmonary development, by the rotation of the fore-gut in the opposite direction, carrying the vagi with it. These two factors coöperate in determining the plan of pulmonary development. Whereas, on the right side the vago-arterial interval is widened as a result of these rotations and the avenue for the right eparterial expansion is opened up, the path on the left side is blocked by the approximation of vagus and left pulmonary artery. It is especially the massive trunk of the nerve which would stand in the way of a bud advancing from the left stembronchus dorsal to the artery, or would, at the most, permit its development only rarely, as a variant, supplying a limited peripheral pulmonary area.

Absolute proof of the above outlined genesis of mammalian pulmonary asymmetry could of course only be obtained by the study of the proper stages on embryos of mammalian forms possessing normally the bilateral symmetrical eparterial type of bronchial tree. This material has so far not been attainable.

I have observed, however, that in the Sirenia and in some Cetaceans and pinnipede Carnivores the heart in the adult is practically median

in position with slight, if any, axial rotation. The apex, forming the ventro-caudal point of the heart-cone (bifid in Manatus), is nearly in the median line, and the right and left ventricles have approximately an equal share in the ventricular area of the sterno-costal surface.

The stomach of Phoca vitulina is almost vertical with the omental borders approximating the median plane, in marked contrast to the transverse position of the completely rotated typical mammalian stomach, whose original left surface is directed obliquely ventro-cephalad in distension.

I am inclined to believe that the embryos of bilateral eparterial forms will show a diminished degree of both cardiac and gastric rotation, with consequent greater equality of the vago-arterial interval and a more even opportunity for the development of eparterial bronchial components on both sides.

I am deeply indebted to Prof. F. T. Lewis of Harvard University, for the opportunity of studying three rabbit embryos of the Harvard Embryological Collection (Series 155, 1327 and 1658).

These preparations, perfectly fixed, stained and sectioned, proved of the utmost value.

33. Effects of inanition and refeeding upon the growth and structure of the hypophysis in the albino rat. C. M. Jackson, Institute of Anatomy, University of Minnesota.

Sections (usually serial) of 3 μ to 5 μ were made of the hypophysis from 91 rats, of both sexes. These included 44 normal (newborn to one year), 15 held at maintenance (constant body weight) for various periods by underfeeding beginning at the age of three weeks, 6 adults subjected to acute inanition and 5 to chronic inanition, and 21 young rats refed for various periods after being held at maintenance from the age of three to twelve weeks.

The material was fixed in Zenker's fluid, and usually stained with haematoxylin-eosin, occasionally by other methods.

Volumetric data were obtained for the parts (lobes) of the hypophysis (29 cases), and, in the pars anterior (distalis), for the vessels and stroma, and the nuclei and cytoplasm of the parenchyma (8 cases). The method used was by projection upon paper, the desired areas being cut out and weighed, and the corresponding volumes computed. Direct measurements were also made with the filar micrometer.

1. Volumes of the parts (lobes) of the hypophysis

During normal postnatal growth, there is considerable individual variation in the relative volumes of the various lobes; but on comparing the younger (newborn to three weeks) with the older (ten weeks and above) it appears that in general the pars anterior (distalis) becomes relatively larger, and the pars nervosa correspondingly smaller, the pars intermedia remaining about the same in relative (percentage) volume.

That the hypophysis is relatively heavier in the female rat is already known. The present data indicate that this is due (though perhaps not entirely) to a larger pars anterior in the female.

	PARS ANT.	PARS INT.	PARS NERV.
	per cent	*per cent*	*per cent*
4 males, average	82.0	9.7	8.3
4 females, average	86.4	6.7	7.0

Thus in the female the pars anterior appears to have gained, with a relative decrease in the pars intermedia and, to a lesser extent, in the pars nervosa.

In three rats held at maintenance (nearly constant body weight) from age of three to ten or twelve weeks, the pars anterior appears slightly reduced in relative volume, the partes intermedia and nervosa correspondingly larger. In an adult rat with chronic inanition, the partes anterior and intermedia appear relatively reduced, the pars nervosa increased. In two adults with acute inanition, the pars anterior appears slightly increased, the pars intermedia correspondingly decreased, and the pars nervosa unchanged in relative size.

In several rats refed one-half week, one week, two weeks and four weeks after maintenance from three to twelve weeks of age, there is some variability, but in general a gradual return to the normal proportions in the lobes of the hypophysis, the pars anterior becoming relatively larger, the partes intermedia and nervosa smaller.

In two adult rats which were refed six or seven months after a long period of maintenance (three weeks to five months of age), although the hypophysis as a whole and the body weight are nearly normal, the relative volumes of the lobes are abnormal. The pars anterior is relatively low and the pars nervosa high. This resembles the change found after maintenance and chronic inanition, and may be a persistent effect of the prolonged inanition.

2. Relative size of the components in the pars anterior (Distalis)

In the pars anterior of the normal newborn rat, the vessels and associated stroma form 6.7 per cent by volume, increasing to 9.6 per cent at three weeks, and to 10.6 per cent at ten weeks. In young animals held at maintenance, the volume of the vascular stroma usually increases to about 13 per cent, and in adults under acute or chronic inanition to about 17 per cent. The parenchyma is of course correspondingly reduced in relative volume.

In the parenchyma of the pars anterior, the nuclei form about 34 per cent of the total cell volume in the newborn, decreasing to about 24 per cent at three weeks, and 20 per cent at ten weeks. The cytoplasm undergoes a corresponding increase in relative volume. During inanition, the loss is usually relatively greater in the cytoplasm, the

nuclei thereby increasing to 26 to 28 per cent of the cell volume in the young at maintenance, and to 23 to 26 per cent in adults with chronic or acute inanition.

From the volumetric data, the (calculated) average diameter of the parenchyma cells increases from 10.1 μ in the normal newborn to 11.9 μ at three weeks and 13.6 μ at ten weeks. In the young rats at maintenance the average cell diameter is 9.7 to 10.2 μ and in the adult starved rats 10.0 to 11.0 μ. The nuclei average 5.9 μ in the normal newborn; 5.8 μ at three weeks; 6.0 μ at ten weeks. In the young rats at maintenance the average nuclear diameter is reduced, being 4.9 to 5.3 μ; in starved adults, 5.3 to 5.5 μ.

Direct measurements of the nuclei with filar micrometer give results in fair agreement with those above. The nuclei of eosinophiles are usually slightly below the general average. Nuclei of the pars intermedia are usually near those of the pars anterior in average diameter. For all data there is a considerable amount of variability, both in various individuals and in various parts of the gland in the same individual.

3. Histological structure

Mitoses. In forty cases, the number of mitoses in entire coronal sections of the hypophysis was counted. Marked individual variations occur. In no case was amitosis observed. In the newborn, mitoses are very numerous throughout, the average being 62 in each section of the pars anterior, 9 in the pars intermedia and 7 in the pars nervosa. In the pars nervosa, mitoses soon disappear. At seven days, they are rare, and none were found later (growth thereafter consisting chiefly in the increase of intercellular substance). In the pars intermedia mitosis continues at a diminished rate, the average being 1 in each section at three weeks. At ten weeks and later, they are very scarce. In the normal pars anterior, the rate of mitosis likewise decreases, the average number being 62 at birth, 18 at one week, 7 at three weeks, 2 at ten weeks, and rare in adults.

In young rats held at maintenance from three to ten weeks of age, mitosis has nearly ceased. No mitoses were found in the partes nervosa and intermedia, although in the pars anterior they still occur occasionally, even in rats nearly dead from inanition. No mitoses were observed in the starved adults.

In the young rats refed after the maintenance period, mitoses reappear promptly in the pars anterior, the average number per section being about 2 after one-half week of refeeding, 7 after one week to two weeks, decreasing to an average of 3 after four weeks of refeeding. Mitoses were observed but rarely in the pars intermedia and never in the pars nervosa. The rate of mitosis in the refed rats therefore corresponds in general to that of younger normal rats of similar body weight.

Cell-structure. In the pars nervosa, the only change noted during inanition is a variable degree of hyperchromatism in the nuclei, which rarely may become shrunken and pycnotic.

In the pars intermedia, the cells usually suffer relatively little change in structure during inanition. The nuclei have a variable tendency to hyperchromatism, occasionally becoming pycnotic. The cytoplasm tends to lose its granular structure, becoming more homogeneous in appearance, often finely vacuolated. Around pycnotic nuclei, it is usually more deeply basophilic. Occasionally the cytoplasm may be greatly atrophied and reduced in volume, leaving the nuclei very closely packed.

In the pars anterior, the changes during inanition are variable. Some areas may remain nearly normal, while others in the same gland show extreme changes of atrophy and degeneration. The cytolasm is greatly reduced in volume (as shown above), and is frequently vacuolated. There is a marked tendency to loss of the specific staining reactions, so that strongly chromophilic cells become weakly chromophilic or even chromophobic.

The nuclear changes in the pars anterior are likewise variable in extent and character. There is, however, a very general tendency to hyperchromatism, often reaching marked pycnosis. Karyorrhexis and karyolysis are rare.

Upon refeeding one-half week after the maintenance period (three to twelve weeks), the hypophysis retains the typical inanition structure, although mitosis has begun. After one week of refeeding some areas have become nearly normal, and after two weeks the normal structure preponderates. After four weeks, the hypophysis has usually become nearly normal for the most part, although more or less extensive atrophic areas may persist for indefinite periods.

34. The later development of the lobule of the pig's liver. (Lantern slides.)

Franklin P. Johnson, University of Missouri.

Up until late fetal life the lobules of the pig's liver are fused together and form a continuous mass of liver cells, a condition not especially unlike that found in most adult mammals. It is in stages just before birth before any evidence of a segmentation of the liver parenchyma becomes apparent, and the completion of the formation of connective tissue septae is not fully accomplished until several months after birth.

In the separation of the liver parenchyma the liver cells themselves apparently take some part. The cells along the boundaries of the lobules become granular and stain more readily than the cells elsewhere. Soon they become arranged in parallel rows, or rather sheets, extending from one branch of a portal vein to another, and thus definitely mark out the future lobules. The rows of cells become split apart by a thickening of the reticulum between them. Collagen fibers gradually spread into this thickened reticulum from around the portal veins.

The question of growth of the lobules is of particular interest. Mall (Am. Jour. Anat., vol. 5, 1906) states that "in the pig the lobule measures 0.8 mm. in embryos 4 cm. long until a number of months after birth," adding that "in the adult they are 1.4 cm. in diameter." My own observations are at variance with these. Thus I find beginning

with embryos old enough in which the lobule boundaries are easily recognized, that the lobules gradually increase in size. The following table giving the average diameter of the largest lobules demonstrates this point:

AGE	DIAMETER	AGE	DIAMETER
	mm.		*mm.*
229 mm.	0.35	3 weeks	0.49
254 mm.	0.43	4 weeks	0.51
1 day	0.43	2 months	0.59
3 days	0.45	Adult	1.2

That there is an actual increase in the number of lobules even after the connective tissue septae are formed appears evident from estimates of the total number of lobules based upon volumetric calculations. The additional lobules are formed by a splitting up of certain large lobules. In sections one finds evidence of this in incomplete septae, developing apparently after the manner of the earliest ones.

The conception that the lobules of the liver conform to a general shape and size can be easily disproven. If small blocks of pig liver are treated with 20 per cent nitric acid at 50°C. for several hours, the connective tissue septae are destroyed. The lobules can then be readily teased apart without injuring them. Thus seen, they present a great variety of shapes, some with rounded surfaces and borders, others with flat or concave surfaces and angular borders, some approaching prisms, pyramids and polyhedrons, but the majority are so irregular they liken none of the regular geometrical solids. In size the lobules likewise present great variations within the same liver, some being at least five or six times as large as others. In the adult pig the lobules average about 1.8 cubic mm. in volume, at two months, 0.31 cubic mm., and at four weeks, 0.098 cubic mm.

35. Aortic cell clusters in vertebrate embryos. H. E. Jordan, Department of Anatomy, University of Virginia.

Aortic cell clusters were first described by Maximow in 1909 in rabbit embryos (Arch. f. mikr. Anat., Bd. 73, p. 517). Minot subsequently ('12) described similar structures in human embryos of from 8 to 10 mm. length and in rabbit embryos (Keibel and Mall, Human Embryology, p. 523). Emmel reported ('15) aortic cell clusters in rat embryos, rabbit embryos, and in pig embryos of from 6 to 15 mm. (Anat. Rec., vol. 9, p. 77). Jordan discovered these clusters in pig embryos (10 to 12 mm.) at about this same time, and reported their presence also in mongoose and turtle embryos (Anat. Rec., vol. 10, p. 417). Emmel later ('16) published a detailed description of the aortic clusters of the pig embryo (Am. Jour. Anat., vol. 19, p. 401). Meanwhile I had observed them also in the chick embryos of three to four days' incubation. Danchakoff had already ('07) reported similar struc-

tures in the chick (Folia Haematologica, vol. 4, p. 159). Aortic cell clusters would seem to be a common feature of certain early stages of vertebrate development.

All of the above-named investigators agree in interpreting the constituent cells of the clusters as hemoblasts. Minot alone (l. c.) disagrees with the otherwise unanimous conclusion that they represent endothelial differentiation products. That they are endothelial derivatives, however, rather than accretion products of hemoblasts from the circulating embryonic blood is easy of demonstration. Aortic cell clusters represent one phase of the general hemogenic capacity of embryonic endothelium.

The doctrine of the partial origin of hemoblasts from embryonic endothelium has become associated with the monophyletic hypothesis of blood cell origin (Maximow l.c.); that of the non-hemogenic capacity of endothelium with the polyphyletic and diphyletic hypotheses (Stockard, Am. Jour. Anat., vol. 18, p. 227). The question of the genetic relationship between endothelium and certain cellular elements of the embryonic blood touches also the 'angioblast' theory of His. The two chief tenets of this theory are: 1) the inability of intraembryonic mesenchyme to produce blood vascular tissue, and 2) the incapacity of endothelium to differentiate normally into blood cells. Abandonment of the first tenet has been forced largely through the experimental work of Hahn (Arch. Entwickmech., Bd. 27, 1909), of Miller and McWhorter (Anat. Rec., vol. 8, 1914), of Reagan (Anat. Rec., vol. 9, 1915), and of Stockard (l. c.), and the morphologic studies of Schulte on the cat embryo (Mem. Wistar Inst., No. 3, 1914), those of McClure on the trout embryo (Mem. Wistar Inst., No. 4, 1915), and the studies of Huntington on the development of the lymphatics in amniotes (Am. Jour. Anat., vol. 16, 1914). The disproof of the second tenet is the chief burden of this investigation.

The material studied includes three mongoose embryos of 5, 6 and 7 mm. respectively, a series of pig embryos of from 8 to 12 mm., chick embryos of the third and fourth day of incubation, and a series of twenty loggerhead turtle embryos ranging from the second to the thirty-second day of incubation. These embryos are variously preserved and stained, the several methods including fixation with Helly's fluid and staining with Giemsa's solution.

This description confines itself almost exclusively to the 5 mm. mongoose embryo and the twelve-day turtle embryo. This selected material is at just the proper stage of development to furnish the key for the correct interpretation of the larger aortic clusters of the 10 mm. pig embryos.

The study was approached by way of the yolk-sac of the mongoose embryo. The endothelial origin of hemoblasts can here be readily demonstrated. These observations on the mongoose yolk-sac confirm my previous findings regarding the hemogenic rôle of yolk-sac endothelium in the 10 mm. pig embryo (Am. Jour. Anat., vol. 19, p. 277).

The second step involved a search for similar intraembryonic phenomena. It seemed reasonable to expect that, since the yolk-sac mesenchyme could differentiate directly into blood cells and into endothelium, and since the endothelium could subsequently transform into blood cells, then the same order of events should probably follow also in the intraembryonic mesenchyme; and further, since mesenchyme is the fundamental hemogenic tissue, and since both endothelium and mesothelium in the embryo are only slightly modified mesenchyme, then embryonic mesothelium and endothelium should both, in the only slightly differentiated condition, be capable of producing cellular blood elements.

That mesothelium can differentiate into vascular tissue has been shown by Bremer in the case of the body stalk of a 1 mm. human embryo (Am. Jour. Anat., vol. 16, p. 447). Examination of the intraembryonic endothelium in the pig and mongoose revealed, in the smaller pericerebral blood channels, an occasional endothelial cell rounding up and taking on hemoblast features and finally separating from the endothelial wall; and led to the discovery and detailed study of the aortic clusters of hemoblasts, with the origin and significance of which this study is largely concerned. Moreover, investigation of the pericardial mesothelium disclosed very similar clusters, both attached to the visceral and the parietal pericardium and lying free within the pericardial cavity. Emmel has recently described comparable structures in the 12 mm. pig embryo (Am. Jour. Anat., vol. 20, p. 73). Occasional individual cells can also be seen in process of separation from the visceral pericardium in the mongoose embryo.

As regards the aortic cell clusters, the 5 mm. mongoose embryo shows admirably various early stages in their origin and development, and so furnishes the key to the interpretation of the later products. And the 12 day loggerhead turtle embryo shows besides, the peculiar intravascular encapsulated cell clusters, and the endothelial strands, recently noted also for a 12 mm. pig embryo by Emmel, in a footnote to his paper (p. 407) on aortic cell clusters in mammals; and the conditions in this respect also are such as appear to solve the mystery of their genetic significance.

The aortic cell clusters in the mongoose embryo of from 5 to 7 mm. range from such as are composed of only a single cell to those composed of a score or more. Single cells or groups of two or three can be seen separating from the endothelium at any point, even along the mid-dorsal line. Larger groups are found only in the ventral and ventrolateral portions, frequently in more or less close relation to the mouths of the lateral mesonephric branches or the ventral intestinal rami. This proliferative activity of the aortic endothelium is present only in the abdominal portion of the aorta, approximately coextensive with the mesonephroi. Single endothelial cells may round up and take on hemoblast features and separate from the wall in exactly the same manner as that by which the hemoblasts are derived from the endothelium of the yolk-sac vessels and in the pericerebral vascular channels.

The process is the same in the yolk sac and the embryo, and indicates a common hemogenic capacity of embryonic endothelium.

The mongoose material shows also the initial stages in the formation of the larger cell clusters. Throughout the ventral half of the abdominal aorta, the endothelium at certain points appears to buckle into the lumen. This invaginated area may be more or less extensive, and may include a considerable portion or none of the subjacent mesenchyme. The cause of the buckling remains obscure, though the suggestion lies close to hand that it may be related to the caudal shifting of the embryonic representatives of the celiac, superior mesenteric and inferior mesenteric arteries; a process dependent in part at least upon the presence of a less rigid and less differentiated endothelium ventrally, permitting thus of an inequality of growth as between the ventral and dorsal walls or allowing for the formation of successively lower connecting vascular segments for the migrating definitive stems.

The endothelium seems to be lacking centrally underneath the cell clusters. This is explained by the fact that the larger clusters arise by an invagination of the endothelium over an area of some extent rather than by process of proliferation of one or several differentiating endothelial cells. Proximally the clusters show transition stages between endothelial cells and hemoblasts (laterally) and between mesenchymal cells and hemoblasts (centrally). Within the clusters some of the cells are in mitosis, while the nuclei of others may appear at some phase of amitotic division; and an occasional cell may show phagocytic properties. Sometimes the core of the cluster shows transition stages between endothelium or mesenchyme and hemoblasts. Many of the nuclei subjacent to the cluster appear to be at some phase of amitotic division.

The aortic cell clusters of the mongoose embryo originate from the cells of an invaginated area of endothelium; they enlarge by intrinsic growth and differentiation, not by accretions from the circulating blood. Similar clusters appear also in the superior mesenteric artery. In a 10 mm. pig embryo a large aortic cluster, 130 μ in diameter, occurs near the mouth of the superior mesenteric artery and consists of a hundred or more cells. Clusters occur also along the greater length of this definitive aortic stem.

In the twelve-day loggerhead turtle embryo, encapsulated clusters and extensive strings of hemoblasts attached to the endothelium appear in the inferior vena cava, near the point of fusion of the original paired subcardinal veins. The endothelial strands, some of the cells of which bear hemoblast features, are most probably only another aspect of the general hemogenic capacity of young endothelium. Similar strands appear also in the jugular vein. Emmel (l. c.) saw similar strands in the proximal portion of the left umbilical artery, and in the aorta of this level, in two 12 mm. pig embryos, and suggests that they may be related to the fusion of the two original dorsal aortae. In the case of the development of the inferior vena cava, the coincident fusion between the originally separate post- and sub-cardinal veins in-

volves the formation of young, less differentiated, endothelium and so offers a favorable site for hemoblast production by endothelium.

The encapsulated clusters present in this same region of the inferior vena cava may be explained as follows: Subjacent to such clusters the mesenchyme appears to be differentiating into hemoblasts; this observation may give the clue to the correct interpretation of these clusters. If the invaginating area of endothelium included a considerable portion of such differentiating (vascularising) mesenchyme, then the peripheral cells might possibly be so far outstripped in the expression of their hemogenic potentiality as to be forced, perhaps principally by reason of internal pressure from the differentiating and proliferating cells, to continue development along the line already begun, namely into definitive endothelium.

Emmel (l. c.) interprets the endothelial and mesothelial desquamation products, both cells and clusters, in terms of the stimulative effect of a pathologic factor upon the endothelium; a toxin whose source is in the degenerating cells of atrophying redundant ventral aortic rami, and in degenerating erythrocytes in the serous cavities in the case of the mesothelia.

That atrophying vascular stems are present at this stage, both in relation to the aorta, and the inferior vena cava, cannot be disputed. In the 7 mm. mongoose embryo solid regressive ventral aortic stems are especially conspicuous. At least a portion of the caudal shifting of the three large aortic rami is due to a progressive atrophy of upper portions of a connecting net of vessels. But coincident with this phase of a regressive development among the upper roots, there may possibly be a new formation of lower roots. I incline to see the cause of cluster formation in the latter possibility rather than in the former fact.

Great stress is laid by Emmel upon the structure of the atrophying rami. Some of these are occluded by intravascular collections of hemoblast-like cells, both in the 10 mm. pig embryo and in the 7 mm. mongoose embryo. With these intra-arterial cell masses some of the aortic clusters are intimately related. Emmel ascribes the presence of this intra-arterial mass to the stimulative action of a dilute toxin, presumably liberated by the regressive aortic branches. This explanation is suggested by an alleged comparable pathologic process where endothelium is believed by certain pathologists (e.g., Mallory) to be stimulated to the formation of 'endothelial leukocytes' ('large mononuclear leukocytes') by dilute toxins such as are produced by typhoid and tubercle bacilli. A more likely interpretation, it seems to me, would attribute the presence of the intra-arterial cells mass of the smaller rami to the relatively slightly differentiated character of the endothelium. The occlusion of the rami and the degeneration (karyorrhexis) of the cells would thus be a secondary effect of the constriction of the regressive atrophying vessels. In other words, the intra-arterial cell mass is not the result of the action of a toxin; but the occlusion and degeneration (and the possible formation of a 'toxic substance') are all

the related common sequalae of the shrinking of the atrophying vessel around a previously present, normally produced, mass of hemoblasts.

It may be emphasized that as regards the endothelial origin and the composition of the aortic cell clusters, and as regards the mesothelial origin of cellular elements of the serous fluids, Emmel and I are in essential agreement. But Emmel views these structures as the result of the presence of a stumulating toxin; I see in them only the expression of a normal inherent capacity of embryonic endothelium to produce blood cells. The explanation of the limited distribution of the clusters is to be found in a relationship to young or newly formed, only slightly differentiated, endothelium, rather than in a connection, with regressive blood vessels and an associated toxic substance.

All the facts seem to fit better the hypothesis that the hemogenic activity of embryonic endothelium is a normal function at a certain stage of embryonic development, than that the causative stimulus is a "toxin derived from degenerating vascular tissues."

36. The formation of the anterior lymph hearts and neighboring lymph channels in bufo. Otto F. Kampmeier, Anatomical Laboratories, School of Medicine, University of Pittsburgh.

Because a detailed narrative of the origin and development of the lymph hearts, ducts and sinuses in anuran Amphibians will be published in a comprehensive treatise during the coming year, at this time only the main steps in the formation of the anterior lymph heart and of that part of the lymphatic channel system situated in its immediate vicinity will be presented. This can be most clearly demonstrated by a comparison of six or seven reconstructions of that region in consecutive genetic stages. For the purpose of orientation, it should be remarked that the anterior lymph heart during development occupies a position, at the level between third and fourth spinal ganglia, in the triangular territory bounded medially by myotome, dorso-laterally by epidermis, and ventrally the pronephros and its surrounding venous sinus.

Beginning in 3 mm. toad embryos (European common toad), a series of venous tributaries, following one another in metameric sequence, are formed in connection with the pronephric venous sinus and the post-cardinal vein. They are the intersegmental veins located at the intervals between consecutive muscle segments and confluent ventrally with the cardinal venous trunk, the first three joining the pronephric sinus and the remaining ones the post-cardinal. In 4 mm. embryos we have the first intimation of the future lymph heart. Associated with the third intersegmental vein near its junction with the pronephric sinus, a simple venous plexus appears, as yet crude and indefinite. In the next stage, a 5 mm. embryo, this plexus, the anlage of the lymph heart, has become better defined, and not only does it include the proximal segment of the third intersegmental vein, but it is also united by short channels with the preceding and succeeding intersegmentals, the second and the fourth. Gradually the lymph heart plexus becomes sharp-

ly circumscribed, its meshwork disappears by the expansion and fusion of its channel components, and at the time when the 6 mm. stage is reached, the lymph heart anlage is practically an ininterrupted chamber whose outlines already suggest its definite condition.

Coincident with the genetic changes of the lymph heart anlage, a more or less intricate network is established between the anterior intersegmental veins, that is from the first to the fourth, so that the original metameric condition becomes obscured and finally lost. This plexus, which we may call a veno-lymphatic one in view of its later character, progressively (in 7 and 8 mm. embryos) loses all continuity with the pronephric venous sinus and unites anteriorly with the great cephalic lymph sinus and so becomes intercalated in the lymph system; it thus loses its venous function to assume that of a lymphatic, carrying the lymph stream from the head to the lymph heart. But the original connections of this transformed venous or lymphatic plexus with the heart do not persist to become the permanent ones; they break away from the heart at the same time when the connections with the pronephric venous sinus disappear, so that temporarily the heart is completely isolated except for its confluence on its ventral side with the pronephric sinus by means of a short venous stalk, the beginning of the anterior vertebral vein.

During subsequent stages of development, in 10 and 11 mm. toad embryos, the lymph heart and the dorsal longitudinal channel of the lymphtic plexus again are brought close together, evidently by the expansion of both structures as well as by the relative reduction in extent of the region between the dorsal surface of the tadpole and the phronephros. The approximation between heart and respective segment of the lymph duct becomes more intimate, as is indicated by the fact that the duct comes to lie in a grove-like depression in the dorsal wall of the heart. It is along this line of contact that secondarily an opening or tap is now established, simultaneously with a simple valve, between duct and heart. In the meantime a similar valve has appeared at the lymphatico-venous junction, the connection of lymph heart and anlage of the anterior vertebral vein. The presence of these valves and the pulsations of the heart, which begin approximately at this time, consequently determine the direction of the lymph flow from duct to heart and thence to vein.

Other and later developmental changes as well as a discussion of the homology between the process of lymph heart formation in Amphibia and that in other vertebrates will be considered in the larger paper.

*37. *A comparative study of the roof of the fourth ventricle.* J. J. KEEGAN, (Introduced by C. W. M. Poynter,) University of Nebraska Medical College, Omaha.

At the meeting of the association last year Weed reported a series of injections into the brain cavities of living pig embryos. Independently at that time I had made a similar series of injections into the brain cavities of living rabbit embryos. The technique employed was exposure of the embryo by a small incision through the uterine wall of the anesthetized rabbit and injection of a suspension, solution or dye into the lateral ventricles by means of the finest possible glass capillary tube and bulb pressure. The quantity injected was small and was controlled by an estimate of the rate of flow under a constant pressure. The most useful injection substances were the double solution of 1 per cent ferric ammonium citrate and potassiun ferro-cyanide fixed in 10 per cent formol and 1 per cent hydrochloric acid for the precipitation of the Prussian blue, as recommended by Weed, and the 1 per cent ammonium citrate solution alone, fixed in the acid formaldehyde with the addition of potassium ferro-cyanide which caused a precipitation of the Prussian blue at the site of the citrate solution. The living condition of the embryo was observed in each case by the continuance of the heart beat at the time of immersion in the fixing fluid.

The anatomical findings from these injections, combined with a study of a large number of sectioned pig and sheep embryos and several human embryos, corroborated very closely Weed's results, showing a very early development (pig embryo 6 mm.) of a thin pavement-cell oval area in the roof of the fourth ventricle, which later becomes modified by the development of the transverse fold of the choroid plexus and extends to the area posterior to the plexus.

This area undoubtedly plays an important part in the early escape of the cerebrospinal fluid, as disclosed by the denser collection of protein coagula within the ventricle in contact with this area, its early intimate ectodermal and vascular relation, its later relation to the first region of dilatation of the meningeal spaces and, in all early embryos injected with the double solution, by the collection of the precipitated Prussian blue granules as a dense mass in contact with the inner surface of the membrane.

Injection with the double solution in rabbit embryos up to the age of seventeen days showed no extraventricular spread of the fluid, which was rather surprising in view of the fact that the choroid plexus is quite well developed at this age. Even in the earlier stages before the development of the plexus there is present a rather typical cuboidal-cell layer of ependyma surrounding the membranous area, indicating a possible slight secretion at this age.

For comparison with the double solution injections, which appeared to act in the manner of suspensions or colloids, a series of injections of the ferric ammonium citrate solution alone was made with strikingly dissimilar results. In the stages before the development of the choroid plexus there was a diffusion of the solution into the loose mesenchymal

tissue about the rhombencephalon and only a faint indication of a condensation of the blue granules in contact with the inner surface of the membranous area. After the development of the choroid plexus there was a very rapid absorption into the circulation.

A similar series of injections was made into the midbrain cavity of chick embryos from the four day to the nine day stage, during which time the choroid plexus develops (sixth to seventh day). Similar to the rabbit embryos, in no case did the double solution reach the exterior of the brain cavities or enter the circulation. This was determined by removal and fixation of the entire embryo with its membranes. The same manner of condensation of blue granules in contact with a central membranous area of the roof of the fourth ventricle was noted. In the four day stage this was a rather small oval area in the center of the widely expanded tela of the fourth ventricle. In the seven day stage the tela is constricted at its center by the development of the internal ear and the collection of blue granules is most dense at a small central spot in the anterior half, with a more diffuse collection in contact with the posterior half. On section these areas appear as typical pavement-cell membranous areas similar to the mammalian embryos.

The citrate injections in the chick always diffused into the mesenchymal tissue in the region of the roof of the fourth ventricle and after the development of the choroid plexus (sixth to seventh day) very rapidly entered the circulation. At the seven day stage a considerable portion remained within the ventricle and as a very evident blue coloration in the mesenchymal tissue over the rhombencephalon and mesencephalon. In contrast with this, the double solution injection, remaining an hour in the living embryo, showed no escape from the ventricles.

In the eight and nine day chick the escape of the citrate solution was even more rapid, practically all leaving the ventricles within ten to twenty minutes. Embryos of the same age injected with the double solution and remaining alive for an hour showed no escape from the ventricle.

As this is only a preliminary report of a feature of a more extensive comparative study of the development of the tela choroidea and cranial meningeal spaces in various vertebrate types, final conclusions cannot be given, but the inferences from the material examined are that this membranous area of the roof of the fourth is non-permeable to the double solution in the early embryo stages while it is permeable to the citrate solution; that a slight escape of the cerebrospinal fluid occurs before the development of the choroid plexus; and that the collection of protein coagula and Prussian blue granules in contact with the inner surface of the membranous area represents a dialysis phenomenon of this semi-permeable membrane.

*38. *The structure of the skull of Ziphius.* JOHN D. KERNAN, JR., Anatomical Laboratory of Columbia University.

For convenience the skull of Ziphius is usually described as consisting of the rostrum and the cranium proper, the line of division being drawn tangent to the rostral borders of the maxillary tuberosities. It is well to note, however, that structurally any such division is arbitrary. The rostrum expands at its base both in the vertical and transverse diameters. The transverse expansion, effected by a broadening of the maxillae, reaches its extreme in the region of the maxillary tuberosities. So their rostral borders indeed furnish a valid line of demarcation betwen rostrum and cranium in the transverse plane. On the other hand, the vertical expansion, formed in the dorsal aspect of the skull by the premaxillae, on the ventral aspect by the broad pterygoids, extends much further caudad and reaches the occipital. Thus it is difficult to settle on a point where rostrum ends and cranium begins.

The rostrum is long and exceedingly massive in its structure. It is of interest to consider the mutual relations of the rostrum and cranium. The former is in reality merely the apical portion of a pyramidal mass which rests its base against a ring formed by the supraoccipitals, parietals and the basisphenoid. The junction of the occipital ring and rostral base results in the formation of the great transverse crest of the cranium. From the crest, both caudad and rostrad, the bone falls away toward the foramen magnum on the one hand and rostrum on the other, so establishing the caudal and ventral walls of the cranium. It is the wide expansion of the rostrum at its base which results, in spite of the great length of the structure, in the firmest security against all manner of strains.

In the vertical plane forces are transmitted from rostrum to the occipital ring chiefly through the massive frontal portions of the premaxillae. It must be noted that the chief strength is not gained through direct contact, for only the right premaxilla reaches the crest of the frontal, and that by a narrow process. Between premaxillae and the frontals are interposed the massive nasal bones, and it is through them that thrusts must be in the main transmitted. The surfaces of contact between nasals and premaxillae are broad and the articulations are of great strength.

In union with the premaxillae, the maxillae turn dorsad and reach the transverse crest. This portion of the maxilla, however, is merely a thin sheet of bone and can contribute no great strength in this direction.

On the ventral aspect of the skull the lines of the transmission of force pass through the pterygoids. These bones have a broad articulation with the base of the rostrum, chiefly with the palates which are interposed between them and the maxillae. There is also a small direct articulation with the maxilla and a very slight contact with the vomer. The union then is one of great strength. Caudally the pterygoids reach the bases of the basioccipital processes of the occipital region.

The ventral brace thus formed is much less firm than the dorsal, since the pterygoids are less massive than the premaxillae, and the structure of the bone is less dense. Moreover, dorsal strains are transmitted through a continuous line of bone, whereas the ventral strains must pass through three articulations. We may conclude then that strains in this direction are not so severe as those in the opposite. However, in the adult skull provision for greater firmness is made by the expansion laterad of the borders of the pterygoids which thus secure a very firm hold on the base of the skull.

Lateral strains are provided against by the expansion of the base of the rostrum in the transverse plane. This is effected, as already stated, by the spreading out of the maxillae. Through them forces reach the occipital ring along two lines. One is an inner, along the lateral cranial wall, formed chiefly by the parietals, which articulate directly with the exoccipitals. There is in addition an outer line of transmission through the postorbital processes of the frontals to the jugal processes of the squamosals, and hence to the exoccipitals. That the lines of greatest strain lie through the lateral margins of the bones is at once evident from their formation. Mesally both the maxillae and the frontals are thin sheets which lie in contact and form an articulation of great strength preventing displacements indeed, but offering no great resistance to compression. Their lateral margins on the other hand are thicker. The frontals form the massive orbital processes. These thrust forward strong preorbital processes which are locked to the maxillae by the lachrymals. Lighter postorbital processes reach the jugal processes of the squamosals which interlock with the exoccipitals.

Additional security is given to the rostrum by the character of the articulations of the bones forming in with those of the cranium. On the dorsal aspect the chief of these is that between maxilla and frontal. Both of these bones expand into broad sheets of bone, deeply concave rostrally, the maxillae fitting into the concavity of the frontal. The premaxillae embrace over the mesal margins of the maxillae and secure this border to the nasal and frontal. On the ventral aspect the pterygoid has a broad contact with the base of the rostrum and spreads over the base of the cranium to the basioccipital. Two characteristics then distinguish these articulations, their breadth and a certain amount of interlocking.

To sum up, the relation of the rostrum to the cranium proper, depends for its security on the expansion of its base, and the broad interlocking character of its articulations with the cranium. The central feature of the cranium proper is a great transverse crest, the core of which is formed by the frontals; against it in front rests the base of the rostrum. Its caudal face supports thrusts from the condyles through the supra- and exoccipitals. These bones are reinforced by certain thicknesses which may here be noted as follows: A dense ring of bone above the foramen magnum; a thick crest seen on the inner surface of the skull which passes in the midline from the foramen magnum to the

transverse crest of the skull; two heavy ridges from the caudal ends of this crest running in a latero-rostral direction to the lateral terminations of the transverse crest. Thus the central ridge and the two lateral ridges make together three re-inforcing lines of bone, which transmit the thrusts of the vertebral column to the great transverse crest of the cranium.

39. The laws of bone architecture. JOHN C. KOCH, (introduced by Dr. Warren H. Lewis,) Department of Anatomy, Johns Hopkins Medical School.

Wolff's law of the functional form of bone and the functional pathogenesis of deformity has had as its sole mathematical basis, the analogy first noted by the mathematician, Culmann, between the position of the trabeculae seen in frontal, longitudinal sections through the head and neck of the human femur, and the paths of the maximum tensile and compressive stresses computed for the Fairbairn crane carrying an over-hanging load somewhat as does the upper femur. The Fairbairn crane analyzed by Culmann was assumed to be solid, with a circular cross section and an outline roughly corresponding to that of the human femur with both trochanters removed so as to present a smooth, curved form. The paths of the maximum internal stresses computed in this solid crane (a body entirely different from the femur in shape and in the disposition of the material) were assumed to explain the position of the trabeculae in the upper femur, and to be conclusive proof that the trabeculae in bone are laid down in exact accordance with mathematical laws. Although suggestive, such analogy has never been accepted as conclusive mathematical proof of the law formulated by Wolff.

Wolff's law, though originally based upon faulty evidence from a mathematical point of view, is proved for the normal, human femur by the careful mechanical analysis of the inner structure of the femur; and other important relations between the structure and the stresses due to the preponderant load on the femur-head, are shown by the study presented in this paper.

That human bone obeys the laws governing elastic bodies when carrying a load has been demonstrated by numerous investigators. Therefore the laws of mechanics applicable to elastic materials also hold for bone. After a preliminary study of some thirty femurs, the writer undertook the analysis of the mechanics of the femurs from a 35-year-old subject, who weighed 200 pounds and was in good health at the time of his death by accident.

The object of this work was the exact mechanical analysis of the structure of the normal, whole femur and the determination of the relations between structure and function at every point. The femur was studied in detail in much the same manner as a structural element of a machine or a member of a truss, where the cross section varies greatly from point to point.

The left femur was used for the purpose of studying the bone in longitudinal section, the right femur was used for the analysis of the transverse sections which were made at intervals of one-fourth inch measured along the axis of the bone. The shape of these transverse sections was extremely variable and conformed to no geometrical forms, so that the formulas of calculus could not be applied directly to the mechanical analysis of these sections. Accordingly each transverse section was covered by a series of squares formed by two series of parallel lines at right angles to each other, drawn at intervals of one-twentieth of an inch from the center of gravity of the section. In this manner the area of the compact and the spongy bone was accurately found by the summation of the squares covering these areas: the integration of the product of the area of each strip one-twentieth of an inch wide by its distance from the neutral plane gave an accurate value of the statical moment of the section: the integration of the product of each strip one-twentieth of an inch wide by the square of its distance from the neutral plane yielded an accurate value of the moment of inertia of the section analyzed. These integrations are practical applications of calculus and are absolutely necessary for a mathematical anaylsis of any structure subjected to bending stresses similar to those in the femur. These calculations were made in detail for the femur at intervals of $\frac{1}{2}$ inch in the upper and lower extremities and at intervals of one inch in the shaft. The total number of calculations required in the preliminary studies was about 50,000, and, in the final analysis of the normal femurs studied in this paper, an additional 70,000 calculations were necessary for the analysis of the inner architecture and the computation of the maximum stresses produced in the femur by the load on the femur-head.

An assumed load of 100 pounds was considered as acting on the femur-head in the same direction as the weight of the body, under normal conditions, and the axial load, vertical shearing force and the bending moments were computed for each section in accordance with the principles of mechanics. The amounts of the stresses were then computed at the sections of the femur which had been previously analyzed. As the intensity of the stresses varies directly with the load assumed, the stresses due to any load can be determined by simple proportion once the stresses have been found for a given load.

The load on the femur-head in the normal standing position is 0.3 of the body weight; in walking, the weight carried by the loaded femur-head is approximately 0.8 of the body weight: in running, the dynamic effect of the sudden application of the body weight produces stresses twice as great as in walking, or the effect is the same as that produced by a load double the static load of walking, or 1.6 times the body weight. For the specific case analyzed, the body weight being 200 pounds, the stresses in the loaded femur due to standing, walking and running are those due to a load on the femur-head of 60, 160 and 320 pounds, respectively. Having determined the stresses in the femur for a load of 100 pounds on the femur-head the stresses for standing, walking and running are found by simple proportion.

The inner architecture of the femur is shown by this analysis to be so arranged as to resist economically the stresses produced by the preponderant load, which is that of the body weight on the femur-head in running. The spongy bone in the head and neck of the femur is shown to be arranged in the paths of the maximum tensile and compressive stresses in this region and thus resists most economically these stresses. The spongy bone in the upper femur is well adapted for resisting the shearing stresses which are greatest in the head and neck of the femur. In the shaft the greatest stresses are due to the bending action of the load on the femur-head, which are most effectively resisted by placing the material at a distance from the axis of the bone: in this region the femur is hollow, thus securing efficient resistance to the bending action. At the lower end of the femur the large expansion of the femur by the gradual transition from the compact bone of the shaft to spongy bone in the lower end is made with but a slight increase in the actual amount of bony material used, although the stiffness is more than doubled and the hinge-action of the knee-joint is made very strong against lateral bending. Thus the compact and spongy bone everywhere act in unison to produce an internal structure adapted to the character of the predominant stress at any given point.

The analysis of strength as outlined agrees with the actual breaking-strengths of femurs made by Messerer for loads on the femur-head and also for cross-breaking loads. Statistics of the location of fractures in several independent series of fractures of the femur agree closely with the proportionate distribution of fractures according to the laws of probability, as applied by the writer to the femur.

The writer believes that the evidence presented warrants the following conclusions:

1. The normal external form and internal architecture of the human femur results from an adaptation of form to function.

2. The proportions of the femur are everywhere such as to show a definite mathematical relationship between the body weight and the internal structure of the bone: there is a definite relation between the structure and the stresses at every section.

3. Spongy bone is homogeneous with compact bone as a structural material and differs from it mechanically only in possessing smaller strength approximately in proportion to its relative density as compared with compact bone.

4. The femur has a factor of safety of 5.68 for the stresses due to running, 11.36 for walking and 30.30 for standing.

5. The structure of the femur is based upon the mathematical requirements of mechanics and the inner architecture is such as to produce great strength with a relatively small amount of material; the material is arranged to correspond with the stress requirements existing at every section.

6. The adaptation of form to function, proved mathematically for the normal, human femur by exact mechanical analysis, is the general law of normal bone.

7 . The thickness and closeness of spacing of the trabeculae in bone varies directly with the intensity of the stresses transmitted by them.

40. A comparison of the Herzog and Strahl-Beneke embryos. (Lantern.) Frereric T. Lewis, Harvard Medical School.

The Herzog and Strahl-Beneke embryos are of particular value to embryologists since they are the youngest human embryos of which satisfactory drawings of serial sections have heretofore been published (22 sections of the Herzog embryo and 60 of the Strahl-Beneke specimen). Of the Peters embryo, apparently only a single section is thus available, which has been reproduced everywhere; and although 30 sections of the Bryce-Teacher specimen have been published, they are fragments defying interpretation, at least apart from the specimens themselves. Bryce and Teacher estimate that their embryo is three days younger, and Peters two days younger, than the Beneke specimen; but that these figures are merely approximations is indicated by the fact that Bryce and Teacher consider Peters embryo to be thirteen and one-half to fourteen and one-half days old on p. 53 of their work, but fourteen to fifteen days on p. 59. Although the difference in age of the four specimens under discussion is perhaps not greater than three days, there is the widest difference in the amount of information available about their structure. The Strahl-Beneke and Herzog embryos are the ones to which at present we must resort for an approximately adequate description.

Herzog's embryo is not now in a good state of preservation and its reconstruction is in part a matter of restoration. Thus the detached tube in the body-stalk, which was originally interpreted as an allantois, is clearly an amniotic duct. The place where it was torn off from the amnion can be definitely located. (This fundamental correction, reported at the 1913 meeting of this association, involves a change in labelling rather than any other modification of the model figured by the writer in Keibel and Mall's Embryology, vol. 2.) The Strahl-Beneke embryo is in far better condition, and helps to explain the Herzog specimen, whereas the latter is the most interesting commentary on Strahl and Beneke's important publication. This was appreciated by Strahl and Beneke who expressed regret that Herzog's paper was received too late for them to make a detailed comparison between his sections and their own, and they merely note that his sections differ in many respects very strikingly from theirs. We can now supply such a comparison and find that the embryos are so nearly alike that they may be said to establish the essential features of a certain early stage in human development. The conditions in younger human embryos are still subjects for diagram and conjecture.

41. Further observations on the longitudinal muscle of the pig's colon. P. E. Lineback, Atlanta Medical College, Emory University.

The longitudinal muscle of the pig's colon develops from an accumulation of myoblasts, which are earliest seen in a 39 mm. embryo, at the

mesenteric arc, and rapidly spread around the circumference of the bowel. The mesenteric arc also first shows fully formed muscle fibers, which are grouped into a crescentic form, and from the tips of the crescent growth extends laterally till the whole circle becomes changed into a layer of muscle fibers; completed at 140 mm. All the while the crescentic thickening is the most conspicuous part of the muscle, a condition in harmony with what F. T. Lewis finds in the human embryonic colon.

Up to the 140 mm. stage no accumulations of fibers appear which can be interpreted as taeniae. After this time two thickenings develop in the muscle, one at either side of the intestine, equidistant from the mesentery, which receive the greater number of mesenteric vessels, and become the permanent taeniae; the only bands which the pig's colon possesses. The mesenteric arc never becomes a taenia, except in the caecum where it extends from the tip of this pouch to the ileum, at the line of attachment of the ileocaecal membrane.

42. Observations on the effect of Madder-feeding, especially with regard to deposits of calcium-salts. C. C. Macklin, Johns Hopkins Medical School, Baltimore, and Wistar Institute of Anatomy and Biology, Philadelphia.

It has recently been shown that the physical and chemical processes underlying the formation of normal bone and of pathological calcific deposits are similar, if not identical. Furthermore, it has been known for many years that the dyestuff, madder, when fed to animals, will specifically stain the calcium-salts of bone which are being laid down during the time that the coloring matter is present in the circulating blood, and that this is true for the callus formed in the repair of injuries, as well as for the bone of normal development. It seemed reasonable, therefore, to suppose that the same staining reaction toward the dyes of madder would be evidenced by calcaerous tissue of a pathological character as is shown by developing bone. Accordingly, madder was fed to animals which possessed calcium-salt concrements of different kinds, and the results were studied. In general it may be said that the behavior of pathological calcium-salt deposits toward the dyestuffs of madder was identical with that of bone.

The work was carried on principally with the white rat. Experimental calcification of the kidney was initiated in the well known way by unilateral ligation of the renal vessels. After a short time the kidney, which is revascularized through the adhesions of the surrounding peritoneum, becomes the seat of a process of calcification, so that upon cutting through the organ numerous hard nodules of calcium salts are found in its interior. During a part of the time when this deposit of calcium-salts was forming madder was fed, with the result that the deposit was stained. Not all of the calcium-salt aggregation was colored, however, the nodules being composed of both white and red granular masses. These latter were probably laid down during the time that madder was being fed to the animal. Thus the picture

presented by such a stained concretion recalls that of madder-stained growing bone.

Madder was fed to a young rat which presented a double cataract, with the result that a distinct pinkness of the eyes was noticed in three days. The animal was killed after six days' feeding, and the lenses cleared in oil of wintergreen. It was then seen that the red staining was at the periphery. This was also evident in the sections. Most of the calcific deposit was unstained, the red areas representing the part of the cataract formed in the six days during which madder was being fed. Normal lenses do not stain with madder, even after five months' continuous feeding.

From these results it is believed that all pathological calcific deposits in process of formation will stain with madder.

Since calcium-alizarate, an insoluble precipitate of alizarin, has been shown to be responsible for most of the staining of bone in the madder-fed animal, it may also be regarded as the principal staining agent in the case of the pathological concretions.

This identical staining reaction towards madder-dyes on the part of both developing bone and developing pathological deposits of calcium would seem to strengthen the conception that the processes involved in their formation are largely identical.

It was noted that the dyes of madder pass easily through epithelia of different characters. The observation that the bones of the fetus are stained *in utero* by feeding madder to the mother was confirmed, and it was also noted that the milk of the madder-fed mother was colored pink, and readily stained the bones of the young suckling animal. Furthermore, madder is freely excreted by the kidney. The urine is yellow or orange when passed, but this color is turned to a red upon the addition of an alkali, thus indicating the presence of alizarin. Madder-dyes may be absorbed by serous membranes and excreted by them. Proof of the former statement is afforded by the staining of the bones in the usual way following the introduction of a sterile madder-decoction into the peritoneal cavity. The latter assertion is illustrated by the pink color shown by the hydrocele fluid of an animal fed with madder.

In animals fed for three months continuously with madder the cartilage was permanently stained red. Transient staining of the lining of the cardiac end of the stomach was noted even after only a few days' feeding. This coloration was found in the superficial layers of the keratin-like material which covers the squamous epithelium in this region. It is due to direct contact with the dyestuff.

Madder-feeding was without apparent effect on growth and reproduction.

43. Influence of heat on the eggs of Cumingia. MARGARET MORRIS, Osborn Zoological Laboratory, Yale University. (By invitation.)

The following report is a continuation of the cytological study of the influence of heat on the eggs of Cumingia. In the report made last

year, it was shown that if the eggs of this mollusc are subjected to certain temperatures they undergo a sort of self-fertilization. The first polar nucleus is separated from the egg nucleus, but is retained in the cytoplasm of the egg, and the two nuclei fuse to form a cleavage nucleus. In the ensuing cleavage the form and number of the chromosomes is abnormal. Instead of 36 long threads such as are present in the normal egg, there are 50 or 60 short rods. It was supposed when the retention of the polar body was first observed that this process would result in the restitution of the normal chromosome number, but though the normal amount of chromatin is undoubtedly present, the number of chromosomes is much larger than the diploid number.

It has been found in more recent experiments, that if the eggs are fertilized and subjected to heat immediately after fertilization, the chromosomes of the first polar spindle behave as they do when the unfertilized egg is heated. They divide, as in the normal egg, and go to the poles of the spindle, where they form a number of small vesicles. These fuse gradually and two large nuclei are formed. This takes place without any cytoplasmic cleavage, so that here, as in the parthenogenetic egg, the egg nucleus and the polar nucleus are both present. In the meantime, however, the male pronucleus has undergone perfectly normal development, so that the egg contains three nuclei instead of two. Each of these nuclei contains the haploid number of chromosomes: they come to lie close together and fuse in most cases to form a single cleavage nucleus. In some instances the male and female pronuclei do not fuse before the cleavage spindle begins to form, but there is never any discarding of nuclear material. The first cleavage spindle, then, should have a plate of 54 chromosomes or three times the haploid number. Here, as in the case of the parthenogenetic eggs, the theoretical expectation is disappointed. The first cleavage spindles have about 60 chromosomes—one plate that has been counted shows 62, another 58. Although the number is about the same as that found in the parthenogenetic eggs and the oultines of the chromosomes are similar, a great difference in size is noticeable, for the chromosomes of the fertilized egg are much larger than those of the parthenogenetic one. Evidently a larger amount of chromatin is present in the fertilized egg divided into about the same number of bodies.

It was thought that perhaps the abnormal shape and number of the chromosomes in these eggs was an effect of heat which would be reproduced in normally fertilized eggs which had formed polar bodies. If this effect is one of heat only, such eggs should show equatorial plates like those of the parthenogenetic (self-fertilized) eggs. Experiments were made in which the eggs were fertilized and allowed to form polar bodies, and heated before the first cleavage had taken place. The cleavage spindles in the eggs treated in this way show a condition entirely different from that of the parthenogenetic egg. The chromatin is present in the form of large irregular masses which give the spindle an appearance similar to that of the first maturation spindle of the normal egg. The presence of the two polar bodies shows, however, that we have here an abnormal cleavage spindle.

The amount of chromatin present in the egg is an important factor, for it has been shown that eggs having less than the diploid number of chromosomes are incapable of development. The addition of extra chromatin, on the other hand, is not injurious to the egg, for those that have three times the haploid number develop fairly regularly. The number of chromosomes present in cleavage varies under experimental conditions. It is interesting to note that the mean about which this number varies is not the diploid number, but is nevertheless the same in eggs which have the diploid and in those which have a triploid amount of chromatin.

*44. *Studies on the mammary gland.* J. A. Myers, Institute of Anatomy, University of Minnesota.

1. The fetal development of the mammary gland in the female albino rat

Henneberg ('00) made a careful study of the development of the mammary glands in the albino rat from the earliest appearance of the glands through the conditions found in 16 day fetuses. Also the postnatal (birth to 10 weeks) development of these glands has been investigated (Myers '16). Heretofore the developmental conditions between 16 day fetuses and newborn rats have presented a gap in our knowledge of the mammary gland. The object of the present investigation is to fill up this gap, thus completing the history of the mammary glands in the albino rat to ten weeks of age.

In 17 day and 2 hour fetuses slight mammary pits appear on the surface of the skin over the mammary gland areas forming the typical 6 pairs. The primary ducts are solid epithelial invaginations measuring only about 0.05 mm. in length. Secondary ducts have not yet appeared.

Wax reconstructions and serial sections show very definite mammary pits in 18 day 9 hour fetuses. The primary ducts remain unbranched except in the abdominal glands where short secondary ducts appear. A small end-bud is present at the terminal end of each duct.

At 20 days, 6 hours the mammary pits are still present but in the deepest part of each pit is a small eminence surrounded by a shallow furrow. The eminence corresponds to the future nipple. Deep to the shallow furrow there is a short ingrowth of epithelium which forms the epithelial hood described in postnatal stages. Secondary ducts are present in all of the glands. In the abdominal and first inguinal glands tertiary and terminal ducts were observed. The terminal ducts present well developed end buds. In many of the terminal ducts lumina are quite well formed. The lumina begin at the distal end of the tertiary ducts and terminate about 30–40 μ from the distal end of the terminal ducts.

2. A comparison of the mammary glands in male and female albino rats

In the postnatal stages observed mammary gland nipples have not appeared in the male rat, although as previously shown they are very conspicuous in the female.

Male fetuses of 18 days 9 hours present no mammary pits. Instead there is corresponding to each gland a slight eminence covered with thickened epithelium. The ducts are similar in size and form to those of the female fetuses of the same age.

At 20 days and 6 hours there is neither pit nor eminence over the mammary gland areas but the ducts come directly to the surface, the epithelium of which is slightly thickened. The epithelial hood found in female fetuses of this stage is absent. The ducts of the male have branches and lumina corresponding with those of the female.

45. The history of the eye muscles. (Lantern.) H. V. Neal, Tufts College.

The attempt is made in this paper to demonstrate on the basis of embryological evidence the exact homology of the first three permanent myotomes of Amphioxus, Petromyzon, and Squalus and to describe the more important stages in the phylogenesis of the eye muscles.

The evidence is presented for the first time to support the assertion of Dohrn ('04) and the writer ('07) that the second as well as the third myotome participates in the formation of the external rectus muscle. In the light of the evidence given the familiar text-book formula for the ontogenesis of the eye muscles should be amended as follows:

From the first myotome (pre-mandibular head-cavity) arise the muscles innervated by the oculomotor, viz., the Mm. recti superior, internus, and inferior, and the M. obliquus inferior;

From the second myotome (mandibular head-cavity) develop the M. obliquus superior and the ventro-lateral portion of the M. rectus externus;

From the third myotome (hyoid head-cavity) arises the dorso-median portion of the M. rectus externus.

46. The early morphogenesis of the thyroid gland in Squalus acanthias. E. H. Norris, (Introduced by C. M. Jackson) Institute of Anatomy, University of Minnesota.

The anlage of the thyroid gland in Squalus acanthias makes its appearance in embryos of approximately 4.0 mm. in length, as a solid epithelial bud from the floor of the posterior pharynx. This bud, which is at first little more than a thickening of the entodermal lining of the pharynx, is placed just ventral to the point at which the oesophagus leads from the pharynx, and in the region inferior and caudal to the ventral extremities of the first two gill pouches. The bud increases in size and extends caudally. It assumes a pedunculated form, being suspended from the floor of the pharynx by a rather extensive but very narrow neck. By the time the embryo has attained a length of 19 mm.

the gland has severed its connection with the pharynx, and has the form of a column with rounded ends and whose cross-section is ovoidal. At 28 mm. the gland has once more changed its form, appearing at this time as a relatively thin diamond shaped plate. At 36 mm. the gland has increased remarkably in length and is divisible into an anterior, diamond shaped corpus and a posterior, elongated, narrow cauda. During the previous stages the gland has presented surfaces which have been quite smooth, but at 48 mm. the surfaces begin to lose their smoothness and by 100 mm., which approximately marks the end of the prefollicular period, the surfaces have been greatly altered by the development of great numbers of small ridges and furrows.

While these changes have been altering the external gross form of the gland, various other changes have been in process within the gland mass. Two of these deserve particular note. During the period immediately preceding the separation of the gland from the pharnyx a large amount of pigment has been deposited in the gland. Although this pigment is not confined to any particular part of the gland, by far the largest part of it is found in the narrow and constricted neck which suspends the gland from the pharyngeal floor. The pigment disappears after the gland has gained its independence from the pharynx. The second process is that which has to do with the development of completely closed cavities within the gland mass. It is important to note that these cavities are quite distinct from the follicular cavities which develop later. They finally open to the outside and are invaded by the vascular mesenchyme. These cavities are produced by the vital activity of the cells which rearrange and redistribute themselves about the forming spaces. By the appearance of these intraglandular spaces the gland is transformed into a number of irregular epithelial plates, two cells in thickness, in which the primary follicles develop.

These findings, as regards the development of the primary follicles from the two-celled epithelial plates, are of particular interest in the light of recent work upon the early development of the human thyroid.

47. On the position of the vitelline arteries in human embryos. (Lantern.)

James W. Papez, Atlanta Medical College, and Frederic T. Lewis, Harvard Medical School. (Presented by Professor Papez.)

This paper is a continuation of the study of the mesenterium commune reported at the last meeting of the association. The relation of the mesenteric artery to the rotation of the intestine can now be more fully considered. Broman, in 1914, declared that the proximal part of the definitive vitelline artery arises, as is well known, by the fusion of a pair of ventral aortic branches. Evans ('12) reviewed the evidence that instead of fusing, either the right or left members of an original pair may shift to the median line and become the persistent vessel, and he concluded that "the question is an open one." The formation of the very short median stem which by great elongation becomes the superior mesenteric artery, requires an anastomosis or par-

tial fusion between the right and left vessels, but not necessarily a complete fusion. Sections of the successive median roots of the mesenteric artery in a single embryo seem to show that sometimes the vessels fuse from the aorta outward, and sometimes one member of a pair enlarges as its mate becomes obliterated. After the short median vitelline trunks have been formed and have anastomosed antero-posteriorly to make the final superior mesenteric artery, that vessel increases rapidly in length and caliber. In an embryo of 4.6 mm. its trunk divides into several branches which encircle the intestine and re-unite as they proceed to the yolk-sac. The vessels crossing the intestine are remnants of the considerable row of vitelline arteries of earlier stages, and by persistence on one or the other side, they would cause the mesenteric artery to cross on the left or right of the ileum respectively. Usually the persistent vessel crosses the intestinal tube on the right side as seen in a 7.5 mm. embryo.

At 10 mm. the intestinal loop has dropped downward over the artery, which then appears below the ileum; and at 14.5 and 22.8 mm. the artery is seen on the left side of the small intestine. Nevertheless it is morphologically on the right side, as is made apparent by undoing the effects of intestinal rotation. In all these stages it does not become free from the mesentery until it is about to cross the intestinal tube. (The same is true of the vitelline vein, but since the latter crosses the duodenum, it has a long course as a free vessel within the abdominal cavity).

In an embryo of 44.3 mm. the intestines are entirely within the abdomen. The vitelline artery has now become free from the mesentery for a considerable distance before reaching the ileum. Thus it comes out from the left side of the mesentery as a strand which extends to the umbilicus. Owing to further rotation, the intestinal tube seems to encircle it completely; but again by undoing the intestinal rotation the artery is found to be morphologically on the right side. An unusual case in which the left half of the peri-intestinal arterial ring persisted, so that the vitelline artery crossed the intestine on the left, was found in an embryo of 42 mm. This shows conclusively that the artery may persist on either side of the intestine without modifying the direction of the intestinal rotation, and the same is true of the vitelline vein, which in an abnormal embryo modelled by Begg crossed the duodenum on the right. Usually the vein persists on the left side of the tube and the artery on the right side, but these are not essential factors in directing the intestinal rotation.

The vitelline artery, as found by Dexter in the cat ('00) anchors the ileum to the umbilical hernial sac so that the jejunum re-enters the abdomen first and the ileum last of all, stretching the artery to a filamentous strand. This order of return has been confirmed by Broman for the seal, and is probably applicable to man. After the arterial strand ruptures (which usually takes place in embryos somewhat older than those studied, though the strand may exceptionally persist until birth, and rarely through adult life) the place of its at-

tachment to the mesentery may be indicated by an appendage of the mesentery, which Broman finds invariably in seals and names the appendix meso-ilei. According to Fitz, who made an important clinical study of omphalo-mesenteric remains in man ('84), Ruge described such appendages as frequent, but Fitz admits that he himself sought for them with only indifferent success. The models of the 42- and 44-mm. embryos indicate the position, well on the side of the mesentery, where such appendages may be expected, and it seems quite probable that they have been frequently overlooked.

48. The notochord of an East Indian scorpion. (Lantern.) WILLIAM PATTEN. Dartmouth College.

In a large scorpion, Heterometrus sp.?, recently obtained in Java there is an unusually well developed notochord which presents important new characters of general interest.

A. Embryology. The details of its development are too intricate to be considered here, owing to the presence in it of several different cellular constituents, and owing to its diverse local relations to the spinal cord, to the brain, to their neurilemma sheaths, and to the vascular system.

The main point in its development is that it arises, in close association with the medullary plate, as a median axial cord extending forward from the cephalic end of the 'primitive streak.'

In this important respect it agrees with the notochord of vertebrates and differs fundamentally from the so called notochord of Balanoglossus and of Cephalodiscus. This fact, when its significance is fully appreciated, should effectively dispose of some of the false ideas that have been entertained, since the earliest days of embryology, concerning the 'gastrula,' the 'blastophore,' and the 'archenteron' of vertebrates, and especially of the idea that the notochord is in some way derived from an outgrowth of the alimentary canal.

B. Structure in the adult. General relations. The notochord of Heterometrus is a cylindrical tube, much larger than the spinal cord, extending more than one third the length of the body, that is, from near the root of the tail to the posterior part of the head, or cephalothorax. It lies on the haemal side of the nerve cord, between it and the alimentary canal. The notochord is firmly attached to the nerve cord, its peripheral cells being continuous with those that constitute the neurilemma, and its thick walls, which are relatively firm and elastic, serve to keep the more delicate nerve cord straight and to hold it in place.

Relations to the primordial cranium. In the embryo, the notochord tissue extends as far forward as the forebrain, ending just behind the stomodaeal (infundibular) infolding. The more cephalic portion, however, atrophies, so that, in the adult, the cylindrical notochord appears to terminate abruptly in a point in the hind brain region, although it is continued forward for some distance as a minute, ill defined filament. The cephalic end of the definite notochord lies on

the floor of the endocranium attached to the basilar plate, just inside the occipital ring. In this respect it resembles the anterior end of the notochord in the Cyclostomes.

Relations to the vascular system. The notochord of Heterometrus contains a blood sinus that opens at several points into the vascular system. One opening, at the posterior end, leads into a caudal artery, the others lead into vertical vessels that pass through the floor of the nerve cord, between the longitudinal connectives.

C. Minute structure. The principal part of the notochord is a thick wall of lymphoid tissue containing numerous minute, deeply stained nuclei imbedded in a sharply defined reticulum. Here and there are a few, much larger nuclei, of a very different character, completely filled with very fine chromatin granules.

An ill defined layer of cells forms an outer wall continuous, more especially in the early stages, with the neurilemma of the nerve cords.

A delicate endothelial layer, usually well separated from the notochord tissue, lines the central cavity.

Summary. The available evidence now indicates that the notochord does not make its first appearance in the vertebrates. It first appears in the arthropods, where it occurs sporadically in widely different groups, under widely different structural disguises, and in widely different degrees of development.

While it is to be regarded primarily as a continuous axial organ it may in the same animal be unequally developed in different regions of the body, or present various segmental modifications opposite the ganglionic and interganglionic regions of the nerve cord.

In the vertebrates, the nerve cord becomes more widely established and more uniform in character; that is, it assumes a more constant degree of development throughout the whole class, it extends over a larger part of the body in a given animal, and it is more uniform in character from its anterior to its posterior end.

It will be recalled that the scorpions are the modern survivors of the giant marine Curypterids of the Cambrian and Silurian periods, and that the Curyperids are to be regarded as the probable ancestors of the ostracoderms, and through them of the true vertebrates.

The presence of a well developed notochord in one of the largest of living scorpions is, therefore, a fact of special significance, the more so in view of the facts that in its anatomical structure and in its morphological relations to the alimentary canal, to the nerve cord, and to the cartilagenous cranium, it is in fundamental agreement with the notochord of vertebrates.

Although we have a considerable knowledge of the structure and development of the notochord of arthropods, we have no definite knowledge of its underlying, or primary, function. It is, however, clear in view of its diversified structure in different regions of the same animal and its unequal specialization in different groups of arthropods, that it cannot everywhere have the same function.

In the arthropods, two different functions appear in special cases to be exercised. In some cases the notochord serves as a skeleton, or as supporting tissue; in others it has some obscure relation to the vascular system; or both functions may be exercised, at the same time, in the same animal.

49. The pathological development of a young human embryo. C. W. M. Poynter, Anatomy Department, University of Nebraska Medical College, Omaha.

Doctor Mall has classified pathological ova in four groups as; 1, vesicular forms; 2, ova with neither amnion nor embryo; 3, ova with amnion but no embryo; 4, embryo present but showing more or less degeneration.

This ovum belongs to the fourth group. The chorion, which measures 10 by 8 by 6 mm., was not ruptured; it was mounted in paraffine and sectioned entire.

The embryo is nearly 2 mm. in length, but on account of the unusual development this cannot be taken as an index of age. Estimating from the menstrual history the embryo is about five weeks old.

If atypical environmental factors are responsible for the defective development these factors were probably of a mechanical character, for the chorion seems to be in all respects normal.

The shape of the embryo suggests a development of about 7 somites (Dandy). The neural tube is entirely closed but the differentiation of the brain and cord resemble that of a 3.2 mm. embryo figured by His ('04), except that there is no cephalic flexure.

The body stalk is very much enlarged and represents an outgrowth on the dorsal surface, which is attached to the caudal end of the embryo and extends upward into the amniotic cavity for a distance equal to almost half the length of the embryo.

The circulatory system presents some interesting irregularities. The heart is very much enlarged, extending forward farther than the head, it is roughly 'U' shaped. Only one aortic arch is present on each side and the dorsal aortae are separated throughout their entire length. The right cardinal veins are enormously dilated and there is free communication between the arteries and the veins in the body stalk.

The histological picture is somewhat changed through disassociation (Mall) and infiltration of the tissues with red blood cells.

The embryo furnishes a valuable example of early pathological changes, and in conjunction with a complete clinical history of the pregnancy suggests injury to a normal embryo in the third week of development followed by pathological development for a period for two weeks before death occurred.

50. Some observations on the ossification of the bones of the hand. (Lantern). J. W. Pryor, State University of Kentucky, Lexington.

It is my purpose to call your attention briefly to some of the following observations:

1. The process of ossification is inaugurated much sooner than hitherto supposed.
2. The bones of the female ossify in advance of the male. This is measured at first by days, then months, then years.
3. The chronological order in which the bones of the carpus are ossified is different from that formerly supposed.
4. The bones of the first child, as a rule, ossify sooner than those of subsequent children.
5. Regardless of the variations (normal) the ossification is bilaterally symmetrical.
6. The union of the epiphyses with the shaft takes place much sooner than formerly supposed.
7. Variation in the ossification of bones is a heritable trait.

51. On the use of the word 'sympathetic' in anatomical and physiological nomenclature. S. W. Ranson. Northwestern University Medical School.

Confusion and disorder exist in the literature on visceral innervation because of the lack of a satisfactory and comprehensive terminology which meets the needs both of the anatomist and physiologist. The most important contributions to this difficult subject have been made by Langley, who is also responsible for much of the confusion through the unfortunate use of the term sympathetic. Defined in accordance with the accepted anatomical nomenclature, the sympathetic nervous system is that aggregation of plexuses, nerves and ganglia especially concerned in the innervation of the viscera, glands and smooth muscle. Defined in accordance with physiological usage, the term sympathetic nervous system includes only the visceral efferent fibers of the white rami and their postganglionic connections. The terms used by English and German physiologists are given in parallel columns in table 1. Note the divergent use of the word autonomic.

The choice of the adjective sympathetic is unfortunate in any case having in its favor only the advantage of established usage. It is doubly unfortunate that the term should be employed in two such different senses. If it were possible it would be desirable to drop the word entirely and substitute others in its place. As a first step towards adopting a satisfactory terminology it is necessary to have clearly before us the correct interrelation of the parts to be named as well as a statement of what terms may rightly be regarded as synonymous. These relations are expressed in table 2. In the first column the word sympathetic is retained but with the use of the qualifying terms major and minor. In the second column that word is eliminated with the introduction of one new term "the plexiform nervous system." The third column is the same as the second except that the official term "systema nervorum sympatheticum" is substituted for the "plexiform nervous system."

The major sympathetic system is that aggregation of plexuses, nerves and ganglia especially concerned in the innervation of the vis-

cera, glands and smooth muscle. It is obvious that some term is needed to designate this anatomical complex. While established usage may make it necessary to retain the word sympathetic in this connection, it would be desirable to have a term drawn from some obvious gross characteristic of the system. This would suggest the use of the word plexiform. In any case the name chosen is not of so much importance if we understand that it applies to a gross anatomical complex and carries no implication concerning internal structure and function. The word autonomic cannot properly be used in this connection because it refers to a purely efferent system, while all agree that the complex under discussion contains afferent fibers on their way from the cerebrospinal ganglia to the viscera.

It is therefore necessary and proper to have under the major sympathetic or plexiform nervous system a subdivision including the visceral afferent components. Although the only afferent elements that have been satisfactorily demonstrated are fibers having their cells of origin in the cerebrospinal ganglia, this subdivision would give a place for any other sensory elements that might later be shown to exist.

The autonomic nervous system according to English usage includes all general visceral efferent elements both pre and post ganglionic. It is obvious that the term autonomic cannot be used as an equivalent for major sympathetic or plexiform, because it excludes the afferent fibers and because the autonomic fibers extend beyond the plexiform system through the cerobrospinal nerves into the cerobrospinal axis. The autonomic nervous system includes for instance the cells of the intermediolateral group of the spinal cord and the visceral efferent fibers in the ventral roots. It designates a functional group of neurones which are partly within and partly without the cerobrospinal nervous system. It is therefore correct to say that the major sympathetic or plexiform nervous system contains autonomic components though it does not contain all of the autonomic system. The preganglionic autonomic fibers leave the cerebrospinal axis in three streams: the cranial, thoracicolumbar and sacral. For many reasons, anatomical, physiological and pharmacological, it is desirable to group the cranial and sacral streams together and contrast them with the thoracicolumbar.

The thoracicolumbar autonomics include the visceral efferent fibers of the white rami and their postganglionic connections. This group Langley has called the sympathetic nervous system and we suggest that if this word is to be retained at all the designation be the minor sympathetic nervous system.

The other group of preganglionic visceral efferent fibers make their exit along the III, VII, IX, X and XI cranial and the II, III and IV sacral nerves. These with their postganglionic connections constitute the craniosacral autonomics or the parasympathetic nervous system.

In addition to the afferent and efferent components connecting the viscera with the cerebrospinal axis, there is probably present in the

gastrointestinal tract a mechanism for local reflexes. Such local reflexes, if they exist, must depend upon a mechanism different from that of the autonomic system. In order to give a place in our classification for these myenteric reflex arcs we have added a third subdivision for which we have adopted Langley's designation—the enteric nervous system. This should be understood to include only those elements in the gastroenteric plexuses which are involved in the myenteric reflex.

While it may be necessary to retain the word sympathetic in some anatomical names, it is desirable to restrict its use as far as possible. Such terms as sympathetic ganglion or sympathetic fiber should never

TABLE 1

English and German nomenclature contrasted

AUTONOMIC NERVOUS SYSTEM	DAS VEGETATIVE NERVENSYSTEM
Parasympathetic system	Das autonome system
Sympathetic system	Das sympathische system

TABLE 2

Showing the correct relations of the various parts of the peripheral nervous system primarily concerned with visceral innervation giving synonymous terms in parallel columns

MAJOR SYMPATHETIC SYSTEM	PLEXIFORM NERVOUS SYSTEM	SYSTEMA NERVORUM SYMPATHETICUM
Visceral afferent components	Visceral afferent components	Visceral afferent components
Autonomic components[1]	Autonomic components[1]	Autonomic components[1]
Minor sympathetic components	Thoracicolumbar components	Thoracicolumbar components
Parasympathetic components	Craniosacral components	Craniosacral components
Enteric components	Enteric components	Enteric components

[1] The autonomic nervous system and its two major divisions, the thoracicolumbar or minor sympathetic system and the craniosacral or parasympathetic system, include cells in the brain and spinal cord and fibers in the cerebrospinal nerves and cannot therefore be classed under the major sympathetic or plexiform nervous system. Yet the latter is made up in large part of components belonging to one or the other divisions of the autonomic system.

be used. Since the ganglionated cord is associated only with the thoraciolumbar autonomies or minor sympathetic system we may with good reason retain for it the name—sympathetic trunk. When it is necessary to designate the ganglia of this system by a general term they should be called autonomic ganglia, since they are all essentially relay stations in the autonomic system. In the names of the individual ganglia, plexuses and nerves no qualifying adjective is needed, as for example, the superior cervical ganglion, the carotid plexus and the carotid nerve. Since the Latin name, systema nervorum sympatheticum has never been used in the same loose way as its English equiva-

lent it might be used without danger of confusion if the Latin form were always retained and the English equivalent never used, even to designate the thorocicolumbar autonomics. All things considered the third column of table 2 seems to offer the best solution of the problem, although the synonyms suggested in the other columns may occasionally be useful.

More important than the selection of satisfactory terms is the recognition of the correct relationship of the various parts to be named. It is clear that there is a gross anatomical complex, the systema nervorum sympatheticum or plexiform nervous system. It is also clear that this complex contains autonomic components but not the entire autonomic system and that it also contains visceral afferent fibers. The clear recognition by both anatomists and physiologists of these apparently self evident facts would make possible the adoption of a consistent and uniform nomenclature.

52. Studies in elastic tissue. III. The behavior of the elastica in arteries following ligation and in the organization of thrombi which ensue. (Lantern). J. Parsons Schaeffer, The Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia.

In earlier communcations of this series of studies an account of the behavior of elastica in the occlusion and the obliteration as such of the ductus arteriosus (Botalli) in man and pig was presented. In both instances elastica was found to play an important rôle in the occlusion of the lumen of the postfetal ductus. Many new elastic fibrils were demonstrated; some, doubtless, the product of preformed elastica, others apparently the product of protoplasmic activity of cells in loco and of certain wandering cells which found their way into the occluding mass.

It is a well known fact that elastic tissue behaves diversely in the various pathologic states. Even in the organization of thrombi elastic tissue presents bizarre appearances which seem dependent upon the etiological factor back of the thrombus. In view of the latter, an investigation of the behavior of elastic tissue in arteries after ligation was undertaken. Opportunity was also afforded in this study for observing the behavior of elastic tissue in the organization of thrombi following ligation. This work is merely in a preliminary state and is briefly abstracted herewith.

The rabbit was the animal used for the experimental work. Twenty-five animals were operated upon after the usual technic preparatory to surgical procedures and anaesthetization with ether. Twenty-four animals recovered rapidly from the operation with no apparent ill effects. One animal died of an infected wound.

The common carotid artery of either the right or the left side was secured and ligated at two points, an inch or less of artery intervening between the two ligatures. The distal ligature was usually placed first, thus insuring a blood-filled segment between the ligatures. The ligatures were placed variously: In some instances the endothelial

walls were brought into mere apposition without injury, in others the ligatures were tightly placed with obvious endothelial injury. In most instances the blood was left in the artery segment, in others a slit was cut and the blood was allowed to escape. Again the artery segment was considerably traumatized, in others handled with a minimum trauma. At selected periods after the operation the animals were again etherized and the ligated vessels secured for study.

It is a well known fact that clots may form within blood vessels upon the introduction of foreign material. Injured endothelial cells may act as a foreign substance. In the present series it was found that in those cases in which the artery was ligated gently, i.e., the endothelial walls brought into mere apposition, the blood between the ligatures remained fluid for a relatively long time. However, when the artery was considerably traumatized and the ligatures tightly placed so as to injure the endothelium, intravascular clotting between the ligatures ensued much sooner. Again, the blood became thrombosed in one portion of the artery segment between the ligatures and at another it would remain fluid much longer. Indeed, at some points the blood elements would undergo disintegration and no thrombosis or organization occur in that position. The subendothelial stratum would thicken instead and gradually encroach upon the lumen. Later the cone of the thrombus from another portion of the segment of the artery would grow into the narrowed lumen.

After an interval of from five to twelve days following the ligation, there was found here and there a positive cellular thickening of the subendothelial stratum. It is well to recall that in the common carotid artery of the rabbit, the endothelium at many places rests directly on the inner elastic lamina. At other places a few scattered connective tissue cells intervene. In other words, the subendothelial stratum is for the most part wanting. It seems scarcely possible that the cells in the thickened subendothelial stratum all have their source from the few connective tissue cells in loco. Furthermore, the endothelium is for a considerable time intact and continuous. This is especially so in those cases in which the intravascular clotting is delayed. It is not believed, therefore, that the endothelium contributes to this initial cellular thickening. There is another possible source, viz: the connective tissue cells of the media and adventitia. It is probable that some of these cells wander into the subendothelial stratum and contribute to the early cellular thickening. Indeed, serial sections reveal occasionally connective tissue cells on their way through the inner elastic lamina and at points one can demonstrate a number of cells near the inner elastic lamina looking vertically towards the lumen of the vessel. Of course, in those cases in which the blood early becomes thrombosed and organization sets in, the endothelial lining soon breaks up and undergoes proliferation and doubtless aids in the organization of the thrombus. In such instances the endothelial cells become modified and seem to assume a fibroblastic rôle.

When the blood remains fluid for a long time, the subendothelial stratum becomes thicker and thicker at the expense of the lumen. The enclosed blood is encroached upon. Usually the cone of a growing thrombus from another portion of the artery segment, pushes its way into the constricted lumen. In cross-section the cone of the thrombus is entirely free. Serial sections show, however, it to be a part of a thrombus from another portion of the artery segment undergoing organization.

It is the very early but obvious thickening of the subendothelial stratum that is of prime interest here. Careful study of thin sections reveals in the outlying portion of the exoplasm of the cells in the thickened endothelial stratum very delicate, granular-appearing elastic fibrils. These fibrils in a sense immesh cells, and their appearance, position, and relation indicate that they are the product of protoplasmic activity. At this time the inner elastic lamina appears normal and healthy. The delicate, granular elastic fibrils have no connection with it.

Subsequently the inner elastic lamina, shows here and there a splitting into several layers. In these positions the lamina becomes fragmented, the fragments projecting into the subendothelial stratum and seemingly undergo proliferation in this position. The inner elastic lamina in such positions appears 'moth-eaten.'

The thickened subendothelial stratum is, therefore, made up of connective tissue cells and collagenous and elastic fibrils, the latter of a dual source. When the blood remains fluid for a long time the subendothelial stratum will continue to thicken by a multiplication of these elements and at the expense of the lumen. It reminds one of an obliterating arterio-sclerotic process.

If intravascular clotting early ensues as is often the case the subendothelial stratum has little time to thicken. The endothelial lining is broken up. There is a rapid migration, especially along fibrin bridges, of the elements of the subendothelial stratum and of endothelial cells into the thrombus to aid in its organization. It appears that the endothelial cells assume a fibroblastic rôle in the rapid organization of the thrombus.

The newly formed elastic tissue extends ring-like into the organizing thrombus, forming a net-like mass. This gradually pervades the whole thrombus. Newly formed blood vessels within the thrombus always have very definite inner elastic lamina.

In presenile gangrene, the result of a thrombo-angiitis obliterans probably due to an infection, there is always an absence of elastic fibers save a few around the larger canalizing vessels. Here we have a definite and positive organization of a thrombus with little participation of the elastica. In an arterio-sclerotic process (without thrombosis) in which the lumen of the vessel may become obliterated, we have an abundance of elastic fibers aiding in the occlusion. In the present study where thrombi were experimentally produced under aseptic conditions, elastic tissue plays an important rôle in thrombus organization.

In a few instances a longitudinal slit was cut into the artery segment between the ligatures and the blood allowed to escape. Where the separation of the cut edges was not too great, the elastica aided in the repair. New elastic fibrils were formed from the cut ends of the circular fibers of the inner elastic lamina, in an effort to establish continuity of structure of elastic fibrils. However, where the separation of the cut edges was fairly great, the lumen of the vessel was rapidly encroached upon by endothelium and connective tissue elements. New elastica aided in the occlusion of the lumen, but the cut ends of the circular fibers of the inner elastic lamina did not throw out new fibrils to the same extent as in the positions where the cut edges of the vessels were separated to a less degree. Seemingly when the cut ends of the circular fibers of the inner elastic lamina are less separated, some stimulus is forthcoming to bring about proliferation of the cut ends in an attempt to establish continuity of structure of elastic fibrils. Where the separation is too great, the cut ends of the circular fibers of the inner elastic lamina not only fail to give rise to new fibrils, but they actually seem to undergo disintegration. A study in the larger series is, of course, necessary to draw conclusions. The behavior of the longitudinal fibers of the inner elastic lamina were not studied.

**53. The early stages of the development of the great veins and of the hepatic circulation in the cat.* H. VON W. SCHULTE, Anatomical Laboratory of Columbia University.

That the duct of Cuvier has a more complicated history than is expressed in the familiar statement that it serves to connect the pre- and post-cardinal veins with the sinus venosus, has long been known to embryologists. A model of the great veins of a cat embryo of 5 mm. by Dr. Huntington, shows the participation in its formation of a plurality of elements. Of this it has been stated that "the duct of Cuvier is formed through the confluence of the precardinal, the postcardinal, the omphalo-mesenteric and the umbilical veins." (Huntington and McClure: Am. Jour. Anat. vol. 10, 1910, p. 231 and fig. 25). It is now possible, through the opportunity of suitable material, to record the stages antecedent to the condition above described. In embryos having 12 to 14 pairs of mesodermic somites the umbilical vein extends to the anterior limb bud and receives in addition to plexiform tributaries from the somatopleure, the precardinal vein. This primitive drainage of the precardinal has previously been described by His and by Lewis (Proc. Ass. Am. Anat., 17th Sess., 1903). In the cat at 14 somites the umbilical crosses the omphalo-mesenteric vein dorsally and here opposite the interval between the third and fourth, somites anastomoses with the latter (Mem. Wistar Inst., No. 3, fig. 16).

Subsequently with the lengthening of the foregut and the development of a ventral body wall, the omphalo-mesenteric vein for a segment of its course becomes parallel to the umbilical which has been carried ventrad and now lies against the lateral side of the omphalo-mesenteric. As the umbilical extends to the limb-bud a considerable

segment of it extends cephalad of its communication with the omphalo-mesenteric vein. With this segment the precardinal retains its connection, a portion of the umbilical extending beyond the junction. Additional taps are established between the parallel segments of the umbilical and omphalo-mesenteric veins and a portion of the umbilical is gradually incorporated into the latter vessel. This is accomplished in embryos of 4 to 5 mm. The umbilical now appears as a tributary of the omphalo-mesenteric vein and its cephalic segment gradually falls in line with and forms the continuation of the precardinal. Meanwhile the postcardinal has increased in size and with the resolution of its plexiform connections with the umbilical establishes a secondary anastomosis with the precardinal. The blood from both cardinal veins from this period is carried to the heart through the proximal segment of the precardinal, a portion of the umbilical and finally a portion of the omphalo-mesenteric, the resulting vessel constituting the duct of Cuvier.

The earliest capillaries of the septum transversum make their appearance in close proximity to the entoderm of the foregut in the interval between the omphalo-mesenteric veins and immediately caudal to the sinus venosus. Angiogenesis is active and prior to the appearance of the hepatic diverticulum a plexus is formed which becomes connected at the side with the omphalo-mesenteric veins and cephalad with the sinus venosus. These capillaries are preceded by the formation of angiocysts among which are scattered small blood islands. Many of the vessels are of considerable size with wide irregular dilatations. Subsequently this plexus becomes connected with that about the lung bud and is evidently an accelerated part of the general peri-oesophageal or splanchnic plexus (Davis, Brown).

The hepatic diverticulum is present in embryos of 19 and 20 pairs of mesodermic somites, and naturally is in immediate contact with this plexus of the septum transversum. The ventro-lateral sprouts of the liver invade the septum transversum which increases rapidly in size and continues to be actively angiogenetic. An invasion of the omphalo-mesenteric and umbilical veins is not present until the stage of 4 to 4.5 mm. At this period on the right side a mass of liver sprouts fills the angle of confluence of these vessels and a long falciform process of liver grows out upon the dorsum of their fused segment. Here upon follows rapidly the resolution of this segment into sinusoids and a reduction in the size of the distal segment of both veins. The left omphalo-mesenteric has increased greatly in size, the left umbilical moderately. In the ventral region of the liver the capillaries are abundant and continue to be connected with both omphalo-mesenteric veins and with the sinus venosus. Many of them are separated from immediate contact with the liver sprouts by the interposition of a moderate amount of young connective tissue. This topography and their antecedence in time of the hepatic sprouts, substantiates Mollier's statement of the independent formation of capillaries in the septum transversum and indicates that a considerable portion of the hepatic

vessels are formed before and independently of the resolution of the omphalo-mesenteric and umbilical veins into sinusoids.

*54. *Observations on the osteology of the porcupine fish.* (Diodon hystrix). R. W. SHUFELDT, Washington, D. C.

Several years ago I made disarticulated skeletons of Diodon hystrix, and compared them with others I had prepared of the Burr fishes (Chilomycterus schoeppi); a skull of some species of Ovoides; the skeletons of several species of Spheroides, popularly known as Swell fishes, and of two or three of the trunk fishes, as Lactophys triqueter, L. tricornis and others. Also with the Butterfly-fishes (Chaetodon) and Angel-fishes (Angelichthys), and, finally, with several species of the File fishes of the family Monacanthidae, including Monacanthus hispidus and two or three species of Alutera, the last kindly presented me by Dr. Francis E. Sumner, of Woods Hole, Massachusetts.

This material is before me at the present writing, as well as a series of photographs I have made of not a few of these skeletons.

Jordan and Evermann, in the second part of their most useful work on the "Fishes of North and Middle America," place all of the above-named forms in groups more or less nearly allied to each other. For example, in the Suborder Squamipinnes (or the Scaly-fins) we find the Chaetodontidae, the species of the genus Angelichthys (Angel-fishes), and various others, as the Doctor-fishes, which I have likewise osteologically examined (Teuthis). Following the Squamipinnes, we have the Suborder Scleroderm, in which we have the File-fishes (Monocanthidae); the Suborder Ostracoderm, created to contain theTrunk-fishes, and, finally, the Suborder Gymnodotes, which includes the families Tetraodontidae or the Puffers, the family Canthigasteridae or Sharp-nosed Puffers, and, lastly, the family Diodontidae or Porcupine fishes, in which group we find the subject of my researches of which the present abstract is a brief résumé.

All the Diodontidae are very sluggish fish, and they usually remain near the bottom, slowly swimming about amidst the marine vegetation and the various kinds of corals there found. Their armor-spines are far more formidable than we find them in their relative, the Puffers, and the bones entering into the formation of the mandibles unite so completely in the adult fish, that the sutures almost, if not entirely disappear. This has led some ichthyologists to believe that each jaw is composed of a single bone.

This remarkable fish, with its curious coat-of-mail bearing from head to tail the long, bony, and very sharp spines, may grow to be a yard long, or even slightly longer in some specimens which have been met with off the Bermudas. It is very abundant everywhere in tropical seas, especially in the Hawaiian Islands, coast of Lower California, and from the Carolinas all the way around the eastern coast of North America. It is useless as a food fish, while its odd-looking, spiny skin is frequently found in various places and in collections, blown up and dried as a curiosity; mounted specimens also are preserved in

a similar manner. There are those who believe that the flesh of the Porcupine fish is poisonous if eaten; but there is absolutely no truth in this idea.

Many are familiar with the habit of the Puffers or Swell-fish of blowing themselves up when caught and taken out of the water. A slight scratching of the abdomen will induce the fish to do this. In Diodon this capacity of inflation is very much feebler, though the fish has the power of gulping in sufficient air to cause it to float, belly upwards, on the surface of the water. Many years ago, I saw one floating in this manner in the Florida Straits, when the surface of the water was smooth and at rest.

Apart from the dense and massive mandibular bones and a few of the smaller bones of the cranium, the entire skeleton of Diodon, as in the case of its near allies, differs from that of most true teleosteans, in that the bones composing it are quite elementary in appearance and texture—as though they were composed of a whitish paper pulp rather than of true bone. This does not apply, however, to the spines of its coat-of-armor; they are especially hard and dense, and as strong as steel. When my final paper on the osteology of this fish is published, there will appear in it an account of the most interesting articulations among these spines, which are imbedded in the integuments so that the fish can elevate or depress them at will. After the heavy and massive jaws have been removed, the cranium is seen to be of a sub-cubical form, being almost as broad and as deep on its anterior facial aspect as it is upon its dorsal superficies.

The superior mandible is, as just stated above, a very heavy and massive bone, being composed of the thoroughly fused maxillaries and pre-maxillaries, the sutures between the two being plainly visible, but only faintly in the median line between the premaxillaries. As one bone, it has the form of a broad U, and the corrugated dental plates are similar in the two jaws. On the superior edge of either maxillary there is a free admaxillary.

Viewing the cranium from in front, it is to be noted that it is the nasals that have, in chief, been modified to articulate with the upper jaw; and from them, upon either hand and separated by a wide interval, descends a long column of bone to include the mandibular articulation below. In either one of these columns we have an extraordinary arrangement of the quadrates and entopterygoids.

This is difficult to make clear without the use of a figure of the skull; but such a figure and others have already been made, and will illustrate my final contribution to this subject.

On dorsal aspect, the skull of the Porcupine fish is quadrilateral in outline, the anterior moiety being formed by the large and spreading frontals. All the bones on the roof of the cranium are firmly united together through a peculiar overlapping articulation. Most of the sutures can be made out; while, in the case of others, the boundaries have nearly disappeared in the adult.

There is a small cranial capacity, and the cranial casket is entirely open anteriorly; while anterior to its inferior border the presphenoid passes forwards as a trumpet-shaped bone, with the small end attached to the basisphenoid.

On either side of the skull a rather large symplectic is present, making its usual articulations with the surrounding bones.

The remaining bones of this part of the skull will be fully described later on in my formal monograph on the osteology of this truly remarkable fish.

As in the case of the upper jaw, the mandible is a very massive, U-shaped structure, supporting a row of small teeth, and a somewhat removed, medium, subelliptical plate of others, quite similar to the dental armature in the upper jaw. The articulation with the quadrate is quite extensive.

The bones of the branchial apparatus and tongue are all handsomely developed, but cannot be well described here without the use of figures.

Passing to the spinal column, we find the vertebrae large and unusually well developed for a fish having a coat-of-mail. In the Burr fishes for example, this is not the case, and they possess a very highly developed armor (Chilomycterus). Diodon has the leading eight (8) vertebrae almost devoid of prominent lateral and inferior apophyses. In the ninth vertebrae, however, these suddenly appear, to become broad and spreading in the 12 to 15 vertebrae. There are 20 vertebrae all told in the spine of this fish, and they present some very remarkable characters. The terminal one is much compressed laterally, and very large. It supports, upon either side, a prominent hypural spine, and offers a long shape margin for articulation with the caudal fin, or peduncle. The neural spines supporting the dorsal fin fuse below with the neurapophyses of the 12 to 16 vertebrae, which have their neural spines powerfully compressed laterally, and otherwise modified to receive them. The rays of all the fins are well ossified, and the actinosts thoroughly developed, in some instances of considerable size. The important comparisons of the skeleton of Diodon with those of its near relatives will appear in my formal contribution, as they are of too extensive a nature to be incorporated in the present abstract.

**55. The ovarian cycle in mice.* H. P. Smith, Anatomical Laboratory, University of California.

During the last year a study of the ovulation cycle in mice has been undertaken in conjunction with Dr. J. A. Long, a preliminary report of which has been published elsewhere. On that occasion we presented the results derived from the study of serial sections through the oviducts and ovaries of 61 mice which had been isolated from their litters and from males immediately upon parturition, and killed at varying intervals thereafter. In this way we avoided any possible effect of lactation or sexual excitement due to the presence of the male. That study, which has been carried out over a period of 91 days fol-

SERIES	LENGTH OF TIME BETWEEN PARTURITION AND KILLING	POSITION OF EGGS IN OVIDUCT	CALCULATED LENGTH OF TIME BETWEEN PARTURITION AND OVULATION
121	20 hours	Ovarian one-third	20 hours
186	33 hours	One-third way down	20 hours
216	40 hours	Nearly one-half way down	20 hours
488	48 hours	In second fifth	20 hours
448	48 hours	In ovarian fifth	20 hours
489	60 hours	Two-fifths way down	20 hours
483	72 hours	In last fold	20 hours
490	96 hours	At entrance to uterus	20 hours
491	96 hours	At entrance to uterus	20 hours
414	96 hours	Near entrance to uterus	20 hours
492	108 hours	In last fold	20 hours
494	6 days		
415	6 days		
460	7 days		
416	8 days		
485	8½ days		
486	9 days	In loop leading to last fold	6½ days
463	9 days		
417	10 days		
418	10½ days		
419	11 days		
420	12 days		
450	12 days		
496	12½ days		
421	14 days		
497	15 days		
422	16 days		
498	17½ days		
462	18 days		
423	18 days	Uterine one-third	16⅓ days
447	18¼ days		
432	18½ days		
459	18½ days	Uterine one-fourth	16½ days
484	18¾ days	One-fifth way down	18 days
461	19 days		
424	19 days	Ovarian one-fourth	18 days
434	19 days		
500	19 days		
501	19 days	One-fourth way down	18 days
502	19 days	One-fifth way down	18⅙ days
487	19⅓ days	At ovarian end	19 days
504	19½ days		
439	19½ days		
505	19¾ days		
506	20 days		
425	20 days	Little over half way down	18¾ days
507	20½ days		
426	20½ days	Uterine one-fourth	18½ days
509	21 days		
427	21¼ days		
465	21¾ days		
428	22 days		

lowing parturition, pointed to the conclusion that ovulation in mice occurs spontaneously at intervals of about 17½ days.

The present report of continued work undertaken at the suggestion of Dr. Long, represents an attempt to examine a greater series of cases during the first 22 days post partum in order to detect variations which might occur as regards the time of occurrence of ovulation.

Fifty-two cases are tabulated on p. 92. It will be seen that it is possible to state that the next spontaneous oculation following upon the one which so quickly succeeds parturition occurs between 16½ and 19 days after parturition. The average of the nine such cases observed in this study is 18 days after parturition or in other words a few hours less than 17 days after the ovulation following littering.

A surprising result of the above table must now be alluded to, i. e.: the spontaneous ovulation in question occurred in only 42 per cent of the cases in which it would be expected (9 cases in 21 cases). No explanation is offered for this irregularity.[1] Possibility of individual cases of still greater variation is indicated by one instance in which a second spontaneous ovulation occurred at 6½ days post partum (case 486).

Furthermore, the early part of the present series gives us a good indication of the rate of migration and time of survival of unfertilized eggs in the oviduct of the mouse. A part of the above table may be presented again in the form given below. From it may be inferred that the ovum of the mouse consumes approximately two days in

SERIES	LENGTH OF TIME BETWEEN ESTIMATED OVULATION (TIME OF PARTURITION PLUS 20 HOURS—LONG AND MARK[2]) AND KILLING	POSITION OF EGGS IN OVIDUCT
	hours	
121	0	Ovarian third
186	13	One-third way down
216	20	Nearly half way down
488	28	In second fifth
448	28	In ovarian fifth
489	40	Two-fifths way down
485	52	In last fold
490	76	At entrance to uterus
491	76	At entrance to uterus
414	76	Near entrance to uterus
492	88	In last fold

[1] Since one case of estimated ovulation at 19 days was found it will be well to recognize that other instances of as late ovulation could conceivably be represented by cases 489, 462, 447, and 432, killed prematurely.

[2] Precisely the time of occurrence of ovulation did not interest Long and Mark, but from their careful table of stages of ovulation observed in 19 mice killed from 14½ to 28½ hours post partum one may conclude that in over 75 per cent of all cases ovulation had occurred by the twentieth hour after parturition. (Long and Mark. The maturation of the egg of the mouse. Publ. Carnegie Institution of Washington No. 142, p. 20, table 4, 1911.)

traversing the greater part of the oviduct but that it also waits in the last uterine loop or portion of the oviduct approximately one day or more so that three days must be allowed for the completion of migration.

It was in fact by the use of the second table that estimations of time of ovulation were recorded in table 1.

56. The effect of hypophysectomy upon the subsequent growth and development of the frog (Rana boylei.) P. E. Smith, University of California, Berkeley.

In the operated specimens the hypophyseal rudiment was removed soon after it had commenced to invaginate, that is shortly after the closure of the medullary tube. Controls consist of specimens upon which the operation was unsuccessfully attempted, and of unoperated animals. All animals were reared under identical conditions.

In the hypophysectomized specimens particular attention is called to the non-development of the hind legs; to the pronounced decrease in the size, parenchyma, and colloid of the thyroid gland; and to the profound reduction of the epidermal pigment.

Only one specimen of the group in which the hypophyseal rudiment was ablated, developed legs at the normal rate. Sections show that, although the glandular portion of the hypophysis was totally extirpated, yet the thyroid developed normally and the epidermal pigment was typically reduced.

**57. Changes in the relative weights of the various parts, systems and organs of very young albino rats underfed for various periods.* C. A. Stewart, Institute of Anatomy, University of Minnesota.

Forty-three rats have been used, including 20 controls and 23 test animals. Of the controls 6 were dissected at an average net body-weight of 9.9 grams, 4 at 12.9 grams and 10 at 14.7 grams. The test rats were starved for intermittent periods starting a few hours after birth, and were dissected at the age of three weeks (7 rats), six weeks (7 rats), and ten weeks (9 rats), the average net weight at each age being 10.1, 12.5, and 14.9 grams. On account of the normal variability, and the small number of observations, conclusions are somewhat uncertain in some cases.

As to the body proportions, the weights of the head, trunk and extremities are practically normal in the test rats as compared with the (younger) controls of the same weight. The existing small differences may appear more significant upon the addition of further data.

Of the systems, the skeleton and visceral group (as a whole) show a considerable increase in weight in the test rats. There is also a slight increase in the musculature. The integument is variable, showing an increase in the rats underfed three weeks, but a marked decrease in the later periods. The 'remainder' appears to decrease greatly in the rats underfed three weeks, while in the rats underfed six and ten weeks the change is less marked.

Of the individual viscera, the spinal cord, eyeballs, liver, stomach and intestines (empty), suprarenals, kidneys, testes, hypophysis and ovaries show a definite increase in weight in all three groups. The brain and epididymi show a marked increase in the rats underfed the shorter period (3 weeks), but are doubtful later. The heart and spleen are variable, each apparently losing weight during the earlier fasting period (3 weeks), but increasing in weight so as to surpass the controls during the later periods.

The lungs suffer a considerable loss in weight in all three groups and likewise the thymus (especially at 10 weeks).

There is apparently no marked change in the weights of the thyroid and pineal body.

In general the results agree fairly well with those obtained by Jackson (Jour. Exp. Zoöl., vol. 19, no. 2, '15) in rats held at maintenance for various periods beginning at 3 weeks of age. There are, however, several differences found in the rats of the present experiment, in which the underfeeding was begun shortly after birth. These differences are probably due to the varying tendencies to growth and maintenance among the various organs at this earlier period.

**58. The existence of a typical œstrous cycle in guinea-pigs and its histology.* CHARLES R. STOCKARD and GEORGE N. PAPANICOLAOU, Cornell University Medical College, New York City.

Normal guinea-pigs of our control stock possess a regular periodic proœstrum, occurring every fifteen or sixteen days. This fact was ascertained by examining the vaginae by means of a speculum every day during different seasons of the year. The flow, which marks the proœstrum activity, is not very abundant and consists largely of desquamated epithelial cells and some mucous secretion.

In the first stage there is a flow of a mucous fluid filled with superficial squamous cells of the vagina. A few hours later a thick cheese-like substance occurs in the vagina. This consists almost entirely of the deeper epithelial cells which preserve their eipthelial structure and often remain together in groups or actual pieces of epithelial tissue. This thick vaginal substance after a few hours becomes more fluid in consistency and pus-like in appearance. A microscopical examination at this time shows a very large amount of polymorphonuclear leukocytes among the epithelial cells and the beginning of an active phagocytosis. The result of this phagocytosis is that in a few hours the vagina is almost completely cleaned and no longer contains the menstrual substance except for a little fluid containing leucocytes and a few broken down epithelial cells. The occurrence of either red blood corpuscles or hemoglobin in the menstrual flow takes place only in the later stages.

The active phagocytosis may probably account for the fact that none or very little of the pus-like fluid ever flows out from the vagina. The leucocytes, migrating from the subepithelial capillaries of the uterus and the vagina, as microscopical sections show, attack the desquamated

epithelial cells within the lumen of the uterus and vagina and there begin to destroy them. The entire process of menstruation is not long, its duration being less than twenty-four hours. But during this time the entire genital tract is inflamed by a very active circulation of blood.

The anœstrous period of the uterus and vagina is characterized by the absence of the secretions and the constant presence of leucocytes. Especially the first week after proœstrum, the vagina is very clean and dry. During the second week and particularly a few days before the next proœstrum there is a little mucous fluid in the vagina, and this contains some leucocytes and a few squamous cells. The massive desquamation and the abundant thick secretion, however, occurs very regularly every fifteenth or sixteenth day.

The menstruation or proœstrum seems to be closely followed by an ovulation. At this stage of our preliminary study of the correlation between menstruation and ovulation observations indicate that the ovulation occurs about eighteen hours after the height of menstruation (the presence of the abundant thick secretion).

**59. The morphological changes of the idiosome during the spermatogenesis of the guinea-pig.* C. R. Stockard and George N. Papanicolaou, Cornell Medical School, New York City.

La Valette St. George was the first to describe the idiosome under the name 'Nebenkern' in 1865–1867. Since then this body has been described under many different names in a great number of papers treating the processes of spermatogenesis and oögenesis in different animal classes. Meves ('99), described the structure during the spermatogenesis of the guinea-pig and called it the 'idiozom' (from idios—own, and zoma—belt-). Regaud ('10) proposed a modification of this term to idiosome (from idios –own and soma–body). We accept the modification as better fitting our conception of this structure.

Not very much specific study has been devoted to the idiosome probably on account of the fact that its close position in relation to the centrosomes has made some observers fail to realize that it is in independent body, having its own peculiar history. There is certainly at particular stages a very close relation as to position between the idiosome and the centrosomes, but the relation is temporary. In only one stage in the spermatogenesis of the guinea-pig, are the centrosomes really in very close connection with the idiosome, and this is in the primary spermatocytes. During this stage the centrosomes are enclosed in the center of the idiosome. But as soon as the spireme begins to form they come out of the idiosome to play their usual rôle during the nuclear division, while the idiosome continues its independent development with a surprising succession of highly specialized morphological changes. In the later stages, the secondary spermatocytes and spermatids, no connection is to be observed between the centrosomes and the idiosome.

The idiosome in the male germ cells of the guinea-pig is present even in the spermatogonia. At this stage the idiosome is of somewhat irregular shape and appearance and its internal structure is not clear and definite. First in the primary spermatocytes, the idiosome takes a regular spherical form and shows a clear differentiation into two zones, a peripheral, the idioectosome, and a central, the idioendosome. The latter zone is completely enclosed by the former. When the prophase begins in the division of the primary spermatocytes the idioendosome breaks up into a number of granules the idiogranulomes. During the progress of division, the idioectosome also breaks into smaller pieces, which, together with the idiogranulomes are dispersed throughout the protoplasm. In this way a uniform distribution of the idiosomatic material is secured during the division process.

At the end of the division the idiogranulomes and the pieces of the idioectosome begin to flow together near the daughter-nuclei and thus form two daughter-idiosomes. In the secondary spermatocytes the idioectosome takes a regular spherical shape, while the idiogranulomes form a group of closely arranged granules in its center, as if they were preparing to fuse. A fusion does not take place, however, probably on account of the short existence of the secondary spermatocytes.

During the division process of the secondary spermatocytes the idioectosome again breaks up into small pieces to be distributed in the cytoplasm together with the liberated idiogranulomes. In this way repeating the phenomenon which occurred in the primary spermatocytes. In the telophase a new flowing together of the idiogranulomes and of the pieces of the idioectosome takes place near the new daughter-nuclei, forming the idiosomes of the spermatids.

The idiosome of the spermatids thus has the same formation as that of the secondary spermatocytes, consisting of a large idioectosome containing a great number of small idiogranulomes. The idiogranulomes are each enclosed in a small vacuole, the idiogranulotheca. Soon after the spermatids are formed the idiogranulomes and idiogranlothecae fuse together into larger and larger masses and vacuoles until finally they form a single big body, the idiosphaerosome surrounded by a large vacuole the idiosphaerotheca. The idiosphaerosome, as soon as formed, begins to secrete on its surface furthest from the nucleus a new substance, showing a different color reaction and a vacuolar consistency. This substance, the idiocalyptrosome, covers in a cap-like fashion the remains of the idiosphaerosome now called the idiocryptosome. At this time the idioectosome forms a cap above the idiosphaerotheca and later on when the secretion of the idiocalyptrosome is about complete the idioectosome becomes detached as a separate body. It then moves along the nuclear membrane and finally goes over into the remains of the protoplasm on the posterior pole and is eliminated.

In later stages of development the idiocryptosome comes to lie in the form of a small cap on the anterior pole of the nucleus. The calyptrosome grows into a very large body, always showing a vacuolar consistency. In a still later stage, when the spermatid comes into con-

nection with a Sertoli cell, the idiocryptosome and the idiocalyptrosome are elongated in the form of two cones, the one enclosed by the other. During the final metamorphosis of the spermatid, the cryptosome again assumes the form of a cap, covering the anterior part of the head of the sperm, while the calyptrosome loses its original vacuolar consistency and forms an outer larger cap covering over the inferior cryptosomal cap. The calyptrosome cap and part of the head of the spermatozoön are covered by the idiocalyptrotheca, which is the fully developed and transformed idiosphaerotheca.

A point of special interest is the appearance of small granules, comparable to the idiogranulomes, in the nucleus of the germ cells during all stages of development. These we have termed caryogranulomes. Such granules are to be seen in the nucleus of the spermatogonia, the primary and secondary spermatocytes and the spermatids. The caryogranulomes are usually of small size about that of the smallest idiogranulomes, but in some stages they also seem to fuse together forming large granules. Their appearance, their color reactions and their tendency to fuse all show great similarity to the idiogranulomes, yet no genetic relation was directly observed. The caryogranulomes persist up to the time of the metamorphosis of the spermatid into the spermatozoön. Then they dissolve in the head of the sperm in the same way as does the chromatic material of the nucleus.

The new points brought out by this study are the following: First, The recognition of the idioendosome. Second, The description of the formation of the idiogranulomes through the breaking up of the idioendosome. Third, The persistence and the behavior of the idiogranulomes during the divisions of the primary and secondary spermatocytes. Fourth, The existence of the caryogranulomes and their development. Fifth, The exact manner of the formation of the calyptrosome and its vacuolar structure. Sixth, Certain peculiarities in the development of the cryptosome. Seventh, The double nature of the idiosome, consisting of an ectosomatic and an endosomatic substance, each having an independent development. Eighth, the rôle of the granulation of the idioendesome in serving to distribute the idioendosomatic substance during each division.

**60. Some studies on the venom gland and its excretory duct in crotalus horridus.* VIVIAN STRAHM. Department of Anatomy, University of Kansas. (Introduced by J. Sundwall.)

The venom gland has been studied in several species of reptile. It has been reported by Leydig for Vipera berus (Schultze's Arch., Bd. 9, pp. 598–652); by Emery for Naja-haje (arch. fur Mik. Anat., Bd. 11, pp. 561–569); and by Holm for Heloderma suspectum (Anat. Anz., Bd. 13, pp. 80–85). Dr. Mitchell in his researches on the chemical and physical properties of the venom in Crotalus included a description of the venom apparatus (Smithsonian Contributions to Knowledge, vol. 12).

For my studies, heads from two specimens of Crotalus horridus were used. The reptiles were killed the latter part of January, after about three months captivity, and during their normal hibernation period. The reptiles were chloroformed and the heads severed about an inch behind the jaw. At once, the skin over the glands was reflected, one gland from each head removed, and cut into small pieces. Part of these bits were fixed in neutral form-Zenker, the remainder in Bensley's aceticosmic, bichromate mixture. The heads with the remaining glands undisturbed were fixed in acetic Zenker, and run to 70 per cent. The small pieces were used for histological demonstrations; the heads, for gross structures and relationships.

The venom gland, a flat, smooth oval body, tapering at the anterior end to join the excretory duct, lies on the side of the head above the jaw and behind the eye. The posterior border extends 30 or 40 mm. behind the commissure of the lips. The anterior end lies just below and behind the eye. The gland is thus bounded by the skull behind the eye, the anterior and the middle temporal muscles, the external pterygoid muscle and the skin below and in front of the anterior temporal muscle. The gland is covered with a single layer of dense, fibrous connective tissue. This layer, which is continuous with the layer covering the duct, gives rise to three ligamentous bands and attachment to one.

The excretory duct throughout its course is imbedded in the fascia between the skin and the skull. As it leaves the gland, it is pointed forward and downward. In front of the eye it turns upward, rises to the level of the orbit and again turns sharply downward. It passes under the fossa, around the superior maxillary bone and ends at the base of the poison fang.

The outer surface of the duct is of uniform diameter throughout its length except for a distance of 35 or 40 mm., as it crosses the lateral side of the superior maxillary bone. Here it increases slightly in diameter. Dr. Mitchell noted this thickening and believed it was due to the presence of a sphincter muscle. I found a small mucous gland in this region surrounding the duct. The capsule of the duct also forms the capsule of the gland. No smooth muscle fibers occur in this region nor in any other portion of the duct or gland. This observation is not in accord with that of Dr. Mitchell.

Venom gland and excretory duct

The venom gland is made up of wide branching tubules lined with a single layer of columnar epithelium which is supported by a connective tissue framework. These tubules are short and straight. They are directed backward and outward from their openings. The lumina of the tubules are very wide throughout. The number of tubules seen in any cross section increases rapidly on passing from the anterior to the posterior portion of the gland.

In the anterior third of the gland, on the medial side, a wide lumen forms a receptacle which serves to store collecting secretion. It is continuous with the lumen of the excretory duct.

The lumen of the duct is wide, unobstructed and roughly circular through the three flexures. After passing the third flexure, the walls of the duct are crowded and much folded by the enlargement of the mucous gland which appears in this region.

Leydig has noted a difference between active and resting glands in his specimens. The resting glands resemble the jaw glands while the active glands show very wide lumina and connective tissue trabeculae reduced to thin sheets.

Much the same conditions appear to exist in Crotalus. Of the two individuals studied, one shows glands with very wide lumina filled with coagulated secretion. The connective tissue layers are very thin, widening in many places sufficiently to admit of the passage of a blood vessel. The epithelium is simple low columnar with coarsely granular cytoplasm. Nuclei are round or slightly oval, have scant chromatin and lie near the base of the cell.

The second individual shows connective tissue layers greatly thickened with the cells forming a loose network with many open spaces. The lumina of the tubules are greatly contracted and corrugated. The epithelial cells here are compressed and elongated and several layers are present as a result of the contracted lumina. These cells have dark, coarsely granular cytoplasm and a single nucleus. The nuclei are large, oval bodies with pale karyoplasm, scant chromatin and one or more distinct nucleoli. They lie at different levels though the greater number appears between the middle portion and the base of the cell. The lumina of the tubules and excretory duct contain masses of loose cells. Neutral and other granule stains fail to show the presence of secretion granules in either the active or the resting glands.

The epithelium of the duct is identical with that of the gland tubules.

Interstitial granular cells

This resting gland is characterized by the presence of two types of interstitial cells, which appear only infrequently in the active gland. The first are large conspicuous cells with coarse granules, which are irregular in size and shape. The granules are usually present in such quantities as to completely obscure the nucleus. The granules are deeply stained in all acidophilic dyes utilized, such as picric acid, acid fuchsin, congo red, erythrosin, eosin, methyl orange, orange G., aniline blue, acid green and acid violet. It was found that these granules stain more quickly when the staining solution is placed in the thermostat at 60°C. The acid radicle in such stains as Wright's blood stain and Bensley's neutral gentian affects the granules. In the former, they are stained brilliantly red, while in the latter they are stained orange. They are also stained deeply in iron alum haematoxylin.

The nuclei of these cells when seen are round or slightly oval and lie near the cell membrane. A chromatin network is seen.

These cells are irregularly distributed throughout the connective tissue septa. They are found most numerously surrounding the blood vessels. They are seen also between the epithelial cells of the tubules and in some instances, processes project out into the lumen. The majority, however, are seen in close proximity to the basement membrane at the basal ends of the cells. They are conspicuous between the epithelial cells of the excretory duct, and a few appear in the connective tissue of the mucous gland. These cells have also been observed in abundance in the connective tissue, especially surrounding capillaries, and between the epithelial cells of the vagina dentis.

This picture strongly suggests that these more or less acidophilic cells are passing from the blood vessels through the connective tissue septa and between the epithelial cells into the lumen of the gland, and consequently contributing to the elements of the secretion.

The second type of interstitial granular cells, which appear in much smaller numbers than the first type, are mast-cells and show the structure and staining reactions characteristic of mast cells.

The mucous gland

The mucous gland is entirely distinct and separate from the venom gland. It is, like the venom gland, made up of short, simple columnar epithelium. The excretory duct of the venom gland passes through the center of this gland, and the gland tubules, which lie next to it, empty into it. The main excretory duct of the mucous gland itself is, however, a crescent shaped duct and lies on the under side of the gland mass next to the capsule. Near the external opening which connects with the fang these two ducts join and empty through a common onfice.

The resting cells are tall columnar, with granular cytoplasm. The nuclei are oval with well defined nucleoli and scant chromatin. In some active cells only a small globule of mucin appears near the base of the cell. Again, the whole cell is loaded with secretion.

These secretion laden cells are scattered in the upper end of the tubule but increase rapidly in numbers as the outlet of the tubule is reached. In some tubules, near the outlet, every cell is filled with mucin.

61. Histogenesis of the otic capsule. (Lantern.) G. L. Streeter, Carnegie Laboratory of Embryology, Baltimore.

The cartilaginous capsule of the ear is a favorable place for studying the histological features of the growth of cartilage and its associated tissues, particularly because of two reasons; in the first place, there are, on account of the intricacy of form of the labyrinth, many kinds of cartilaginous changes found there that are necessary to accommodate its growth, including the deposit of new tissue and the removal of old tissue; and in the second place the topography is so well marked by

known landmarks that all of these changes as well as the location and direction of growth can be easily followed. From such a study one is forced to conclude that the tissues of the otic capsule are capable both of differentiation and dedifferentiation throughout a considerable period of their development. This progressive and retrogressive adaptability of the cartilaginous tissue makes possible those changes that are necessary in the growth and alteration in form of the labyrinth.

In the earlier stages the precartilage tissue abuts directly against the epithelial labyrinth. Subsequently the periotic reticulum, beginning along the central borders of the canals, becomes established and spreads at the expense of the temporary precartilage thereby forming a crescentic shaped area of reticulum entirely inclosing the membranous canal. The invasion of the reticulum into the surrounding area of precartilage is brought about, at least in the later stages, by a dedifferentiation of the latter into the former.

At the same time that the precartilage is reverting into reticulum the inner margin of the cartilage that surrounds the canal is dedifferentiated into precartilage, so that a new and more peripheral area of precartilage becomes established as the old area disappears. In this way the margin of the true cartilage gradually recedes from the epithelial canal.

In human embryos 30 mm. long the cartilaginous labyrinth has attained approximately the adult form. Its subsequent development consists primarily of an increase in size to accommodate the growing membranous labyrinth. However, if one compares the superior canal of an 80 mm. fetus with that of a 30 mm. fetus it will be found that the canal has doubled its diameter and has trebled its length and furthermore its linear curvature corresponds to an arc with a longer radius. In reality therefore the developing cartilaginous labyrinth is continuously undergoing considerable changes both in size and form. The enlargement of the cartilaginous canals and their alterations in form and position involves both the excavation of cartilage and also the laying down of new cartilage, the excavation being accomplished by its dedifferentiation into precartilage and reticulum, and the new cartilage being built up, through a precartilage stage, from the periotic reticular tissue. Throughout the entire period of growth of the cartilagenous canals the elements of this continual transformation exist along their margin. The margin during this period is in a state of temporary equilibrium and is capable of advancing or receding as the conditions determine.

The first and relatively the major part of the hollowing-out of the cartilaginous canals is complete before the perichondrium makes its appearance. The perichondrium is formed as a membrane-like condensation of the periotic reticulum which can be first recognized in fetuses of about 70 mm. CR length. In its histogenesis it is analogous to the membrana propria of the epithelial canals.

62. The genesis of the membrana tectoria and its anatomical substratum. O. Van der Stricht (By invitation), University of Ghent, Fellow in Cytology of the Western Reserve University.

In the present paper I should like to present some preliminary results of my investigations upon the histogenesis of the superficial epithelium of the crista spiralis, the sulcus spiralis and of the membrana tectoria of the cochlea.

I had at my disposal cochleae from pig embryos of 60.0, 93.5, 127.0, 137.0, 150.0 and 190.0 mm., from a new born dog and from the following adult mammals: bat, dog, rat and mouse, fixed and stained in various ways.

Crista spiralis. The youngest pig embryos exhibit at the surface of the future crista spiralis and in the greater epithelial ridge, an epithelial layer rather thick, described by many authors; it consists of multiple rows of nuclei, the cells of which trasverse its whole breadth, but the nuclei are arranged at various heights. In reality the cells represent a simple columnar epithelium. The apices of the cells, well visible on tangential sections, figure a very elegant mosaic or pavement, the numerous fields of which are separated by the terminal bars or closing lines (Schlussleisten) and contain each of them, two central corpuscles or diplosomes.

Many authors have shown how the subjacent mesenchyme gradually penetrates between the different epithelial cells of the crista spiralis in more advanced embryos and form a special layer partially epithelial and partially connective. N. Van der Stricht demonstrated that despite this extension the primitive superficial mosaic remains intact, even in the adult organ. Never do the connective tissue elements traverse the system of terminal bars.

In order to get a true picture of the connections between the epithelium and the proliferating subjacent tissue sections tangential to the surface are needed and must be compared with transverse sections. Series of preparations show the gradual thickening of the intermediate ground substance, but in such a manner that rarely is an isolated epithelium cell completely surrounded by the connective tissue. On the contrary, the epithelial cells are arranged and pressed together so that they constitute a system of bands (or sheets) ramified and anastomosed at the surface of the smallest most axial segment of the vestibular lip, near the attachment of Reissner's membrane. The bands are more or less parallel at the surface of a more lateral and larger segment which represents the substratum of the future Huschke's teeth, the axis of the bands being directed from the axial region towards the free edge of the lip. This axis exactly represents the future furrow, separating two developed "teeth." The spaces between the parallel cellular sheets, occupied by the proliferating connective tissue rapidly enlarge, reach their definitive extension and constitute the 'teeth.'

A slightly oblique tangential section at the surface of the crista displays a series of interesting figures, varying according to the depth cut by the knife. From the surface to the depth one sees:

(a) The superficial epithelial mosaic.

(b) Cytoplasmic sheets, parallel on the lateral and anastomosed on the axial segment of the vestibular lip.

(c) A little deeper the protoplasmic bands become nucleated and their nuclei are pressed together in such a way that often no trace of cytoplasm is perceptible between them.

(b) The vascular tissue, areolar in the young, embryonic organ and fibrous in the adult.

The existence of such cellular bands suggests two special questions.

1. At first the possibility of the genesis by fusion of epithelial cells, primitively separated, of a vast syncytium, unexampled in other organs: formed by cells entirely fused along their length but absolutely distinct at their apices where I find, even in the adult persisting distinct centrosomes. Comparing the transverse with the tangential sections already mentioned I have no doubt about the presence of such a syncytial formation at least at some places of the organ. Nevertheless great caution is to be observed before drawing final conclusions for besides very demonstrative figures one sometimes observes sites where primitive intercellular boundaries are persisting partially or even entirely.

2. A second question seems to me at the present time more difficult to solve. Do these multiple nuclei so numerous in this syncytium represent those of the orginally separated cells or do they partially result from the mitosis or amitosis of these nuclei? From the stages of 93.5 mm. (and probably earlier) no mitosis can be found. Should new nuclei appear later it must be admitted that they are formed by a process of direct nuclear division. Although my preparations exhibit some few signs of nuclear amitosis, I am not able to give a final answer to this question.

The structure of the greater and the lesser epithelial ridges is known. I will only point out that the greater thickening from rather early stages shows three more or less distinct segments:

1. A lateral sensorial; very small, beside the lesser ridge; in which appear the inner auditory and inner supporting cells;

2. An axial; the columnar cells of which possess a clear protoplasm and represent the future elements of the sulcus spiralis;

3. An intermediary; between the two preceding; the largest, consisting of prismatic cells, the protoplasm of which is rather dense and dark. The last mentioned cells will provide the epithelial elements covering the region of the foramina nervina.

Tangential sections at the surface of the greater ridge exhibit a very regular mosaic formed by the apices of the columnar cells with their contained diplosomes and the terminal bars separating the cellular fields.

I will not speak of the structure of the lesser ridge studied by N. Van der Stricht who gives an accurate description of its constituents and superficial mosaic.

Membrana tectoria. I have described the generating substratum of this organ, the crista spiralis and the great epithelial ridge and chiefly their superficial mosaic. The last mentioned varies somewhat in aspect according to the site. On the surface of the vesticular lip its fields are large and the closing lines are thin but a little thicker than in the areas covered by indifferent epithelium. (e.g., area of Henle's cells). In the sensorial sections (organ of Corti), they exactly represent the apices of the auditory and sustentacular cells and the terminal bars become very thick (N. Van der Stricht) although they are thin at the beginning of the genesis of the membrana tectoria.

On the surface of the greater ridge the fields are of equal size in the earliest stages but much smaller than on the vestibular lip and the terminal bars are always relatively thick. When the axial segment which first becomes detached from the membrane and inactive (Hardesty) may be distinguished from the intermediate, the fields on its surface are much smaller than in the latter segment.

This system of lines and polygonal fields interferes with the genesis of the membrane tectoria. In previous papers my pupils and I have referred to the paramount importance of the closing lines in the formation of the membrana reticularis of the auditory epithelium, of the membrana limitans olfactoria and of the membrana limitans externa of the retina. I will add here that the zona pellucida of the ovum of dog, bat and other mammals according to my preparations has a similar origin.

My preparations of the duct of the cochlea show that the terminal bars, that is the superficial intercellular cement, condensed, becoming denser and more intensively staining, take part in the genesis of the membrana tectoria in such a manner that they generate the dense part whereas the apices of the cells the more fluid part of the membrana tectoria. But the chemical composition of the dense part is quite different from that of the bars for they take up different stains.

At the surface of its matrix the membrane is formed by a system of delicate lamellae the sections of which represent a reticulum of lines, filaments, in direct continuity with the bars lying over and reproducing exactly in a tangenital section the system of the closing lines. The spaces between these lamellae are filled by a paler substance which seems to be elaborated by the superficial protoplasm of each cell always provided with the centrosome. This fluid like substance and the lamellae may suffer more or less shrinkage and distortion provoked by the fixing agents so that indeed the meshes become smaller or larger and irregular.

In very successful preparations I perceive a similar but irregular network in the sections at the surface of the sensorial epithelium of the organ of Corti. I am thus induced to conclude that the membrane is formed by the same histogenetic process.

This network, first origin of the membrana tectoria, has been described by other authors but erroneously considered as produced by the cytoplasmic summits of the cells (Hardesty, Coyne and Cannieu,

Prentiss). A series of preparations fixed by the new Cajal method shows the terminal bars stained black and the lamellae of the membrane colored in the same manner.

For the wealth of bat material the study of which in the present connection has been very useful to me I am indebted to the generous interest of Mr. W. G. Marshall.

**63. Some anatomical features of the bird hand.* (Lantern.) R. M. Strong, Anatomical Laboratories, Vanderbilt University Medical School.

This work is part of a comparative study of bird anatomy giving especial attention to the Tubinares. The anatomy of the bird hand has been found to need more elaborate treatment than appears in the literature. Fürbringer's exhaustive work dealt especially with the brachial plexus and the muscles of the breast, shoulder, and upper arm.

On this occasion I shall present some details in the anatomy of the albatross hand, with the aid of lantern slides. The mechanism for controlling the flight feathers will be described.

What I gave called the palmar aponeurosis is a part of this apparatus and has not been described in the literature, for birds, to my knowledge. It is continuous at the radial border of the wrist with a dorsal aponeurosis. The palmar aponeurosis merges with fascias of the upper arm, and it gives off slips to the quills of the distal secondaries and most of the primary feathers. It is also attached at points to the phalanges and to the carpo-metacarpus. Further details are not given here as illustrations are needed. This work is planned for publication elsewhere later.

64. On the nature of basal striations in salivary ducts. John Sundwall, Department of Anatomy, University of Kansas.

The presence of basal striations in the salivary ducts, which are characteristic of these ducts, was early noted by Pflüger, R. Heidenhain and Müller, and have been described also by Merkel, Zerner, R. Krause and others, in various animals. That these ducts are concerned in salivary secretion was maintained by Zerner, Eckhard, Milawsky and Smirnow, Solger, and R. Krause among others.

The development of new technique, particularly that for the specific demonstration of mitochondria, has made it imperative that the various glands be made the object of reinvestigation. Much investigation is now going on regarding the presence of and the rôle that mitochondria play in cell cytoplasm. Meves, Bensley, Cowdry, Duesberg, Champy, Hoven, and Arnold, among others, have contributed much to our knowledge of these structures. Whether mitochondria are directly concerned in the production of secretion substances still remains within the field of speculation, notwithstanding that Hoven, Champy, and Arnold hold that such is their special function in gland cells.

Bensley has observed that basal striations in the acinous cells of the pancreas are primarily due to mitochondrial filaments. I also have

observed that when striations were seen in the lachrymal gland, they were dependent upon the preservation of these structures. These observations naturally suggested that the basal striation in the salivary ducts might belong to the same category.

With a view of determining the nature of basal striations in the salivary ducts, I applied Bensley's acetic osmic bichromate, anilin fuchsin, methyl green technique in the preparation of salivary glands taken from the opossum. The mitochondria appear as rods or filaments in the base of the cell, occupying approximately the basal one-third of the cell and terminating as a rule at the base of the nucleus. They are arranged perpendicularly to the long axis of the cell and appear as basal rays in cross sections of the duct. Collectively the basal striation formed by the mitochondria is of the same length in the various cells that make up the salivary ducts. So that in cross sections of these ducts an even deep red fuchsinophilic border is prominent. The border is regular in width and occupies the outer third of the radii of the ducts.

The individual mitochondria making up the basal striations may be generally classified into three groups:

1. Long filaments or rods which extend the entire perpendicular length of the basal striations. As a rule these tend to taper off slightly at both ends and are thickest in the middle. However, many are approximately the same width throughout and terminate bluntly.
2. Short bacillus-like rods of irregular lengths arranged in rows.
3. Minute granules or coccus-like mitochondria arranged in rows or seen more frequently associated with the short rod forms.

Groups 1 and 2 are the types most frequently seen making up the striations. The mitochondrial rods are indeed numerous and are very closely appressed so that under low power observation the characteristic more or less red homogeneous border is noted, especially when sections of 10 or more μ are examined. Observation of sections under 5 μ by means of high power lenses—oil emersion, reveals the rows of mitochondria and individual mitochondria making up these perpendicular striations. The intermitochondrial basal cytoplasm is seen as very narrow strips between the mitochondrial rods. This undifferentiated cytoplasm appears either unstained or as slightly greenish stained clefts between the mitochondrial rods.

In the middle and proximal zones of the cell, the mitochondria are present in the form of minute granules or cocci irregularly distributed throughout the cytoplasm. In some cells they are found much more numerously than in others. Two cells may be seen side by side in one of which they are abundantly present, while in the other only a few are seen.

When the animal has been subject to pilocarpinization, as manifested by the extraordinary secretion of saliva, an interesting phenomenon is observed in the salivary ducts. The mitochondrial rods making up the basal striations show a tendency to lose their perpendicular arrangement and break up into the granular or coccus-like forms. In some

ducts all evidences of the perpendicular arrangement of the mitochonedria have disappeared and the mitochondrial rods have disintegrated into granules. Granules of mitochondria, irregularly distributed, now occupy the basal portion of the cell as well as the proximal portion. The granules are more congregated than in the nonstimulated gland, so appear more numerous, and a granule-free zone of cytoplasm is noted between the mitochondria and the cell membrane.

This description of the stimulated glands represents the extreme picture of the effects of pilocarpin. In many of the stimulated glands the change in the arrangement of the mitochondria is not so marked, and in some the basal striations are only partially disintegrated.

Perhaps the chief value of these observations is the determination of the nature of basal striation of salivary ducts. That this is formed by two elements is apparent—mitochondrial rods perpendicularly arranged (the so-called filaments of Michaelis and Altmann) and an intermitochondrial undifferentiated cytoplasm (the basal filaments of Solger or the ergastoplasmic filaments of Prenant, Garnier, and Bouin). The latter are especially prominent when the mitochondrial elements have been destroyed by the fixation fluids. Bensley differentiated these two elements in his studies of the pancreas.

These observations also explain the inconstant results obtained by investigators and teachers of histology in respect to the basal striations of salivary ducts and other gland ducts. Naturally when the mitochondria are destroyed by the action of certain fixing fluids, such as those containing considerable quantities of acetic acid, alcohol, corrosive sublimate, etc., the basal striations are not distinctly conserved and consequently the sections are of little value for specific teaching purposes.

65. Early development of the cartilaginous ethmoidal skeleton in cat. R. J. Terry, Washington University Medical School, St. Louis.

The first evidence of chondrification in the ethmoidal region was observed in embryos of 12 mm. (crown-rump), prepared by van Wijhe's method; in the ventral part of the future septum nasi are two deeply stained parallel streaks separated across the mid-plane by a lightly stained interval, extending forward from the travecular plate. In embryos of 5 mm. the septum is a single, high median cartilage dividing dorsally into a pair of processes, the parieto-tectal cartilages, which arch over the anterior part of the nasal cavity of each side. A second region of chondrification was found next to that diverticulum of the cavum nasi which later gives rise to the frontal air sinuses. Here a pair of paranasal cartilages is formed independently of the parieto-tectal cartilages behind which they lie. A third contribution to the early ethmoidal skeleton appears in embryos of 17 mm. as a pair of small cartilaginous plates, laminae antorbitales, at the very back of the cavum nasi on either side of the nasal septum. At this stage there is no cartilaginous etymoidal floor. A floor is first indicated in embryos of about 20 mm. by that portion of the paraseptal cartilage which stands

in relation to Jacobson's organ and by the anterior transverse lamina. The posterior portion of the paraseptal and the nasopalatine cartilages appear relatively late. All of these cartilaginous centers, with the exception of the parieto-tectal and possibly the anterior transverse lamina and nasopalatine cartilages arise independently of one another. Nearly complete fusion takes place secondarily between the adjacent edges of the parieto-tectal and paranasal cartilages resulting in the formation of the crista semicircularis within the nose and leaving a small space, the foramen epiphaniale for the passage of the nasociliary nerve. Fusion of the neighboring edges of the paranasal and antorbital plate also occurs; at their junction internally, a small ridge is found where ethmoturbin al I is later developed. Union of the antorbital plate with the septum nasi completes the posterior transverse lamina and posterior cupola of the nasal capsule. The anterior transverse lamina is, at an early stage, continuous with the parieto-tectal cartilage, if indeed it is not originally an extension of it.

*66. *The development of the hemal channels in the central nervous system of the albino rat.* FREDERICK TILNEY and LOUIS CASAMAJOR, Departments of Anatomy and Neurology, Columbia University.

The manner in which the central nervous system acquires its vascular channels is a process presenting several distinctive features. In the first place the neuraxis is devoid of mesenchymal elements for a relatively long period in its ontogenesis. There is a boundary line between mesenchyme and neural ectoderm during this period which is sharp and unmistakable, namely the *external limiting membrane.* In consequence of this separation of mesenchyme from neural ectoderm the neuraxis is lacking for a considerable time in the angiogenetic elements necessary to vascular formation. How, therefore, are these angiogenetic derivatives of the mesenchyme acquired by the central nervous system and what, after their acquisition, are the details of the vasofactive process within the neural tube?

The material selected in the investigation of this problem was the albino rat from somite stages to term and later. As the injection method has been shown to be inadequate for the demonstration of conditions in the early development of the vascular system, this method was not employed. The study was based upon serial sections cut at 5 μ after fixation in Bouin's fluid and stained according to the Mann-Regan method. Reconstructions were also made at magnifications varying from 300 to 1100 diameters.

In the hemal vascularization of the central nervous system of the albino rat, it is possible to discern two more or less distinct phases, the one characterized by the exuberant formation of blood vessels, the other, making its appearance somewhat later, characterized by the selection of the definitive vascular lines and the gradual disappearance of the excess in the earlier, exuberant formation of hemal channels. The dominant feature in the first of these phases is an *angiogenetic process* while the second phase, although still angiogenetic to a marked de-

gree, is rendered conspicuous by an *angiolytic process.* During the phase of vascularization characterized by angiogenesis several stages may be distinguished. For example, in the early somite period of development, not only the neuraxis but its immediate mesenchymal environment are lacking in any evidence of vessel formation. From this absence of all angiogenetic activity, the conditions may be described as the *prevascular stage.* This stage is limited in its duration for embryos as young as 2 to 3 mm. manifest a decided angiogenetic activity in the mesenchyme immediately surrounding the neural tube. The mesenchymal cells are collected in scattered groups which border upon the external limiting membrane. Near the center of many of these groups erythroblasts in the several stages of their evolution are seen. In many instances the hemopoietic mesenchymal elements are still in part attached to the surrounding mass of mesenchyme. In other instances the erythroblasts lie wholly detached within well-formed endothelial spaces. During this stage it is possible to recognize in the perineural mesenchyme blood islands and isolated endothelial spaces containing blood cells. Thus the vasofactive process, giving rise to isolated endothelial spaces, goes hand in hand with the formation of perineural blood islands from which latter the endothelial spaces and erythroblasts are derived. It is essential to note that at this particular period there is no evidence of vascularization in the neural tube and for this reason the conditions may properly be described as the *stage of perineural angiogenesis.*

In embryos of 3 to 4 mm. length a notable and critical change occurs. The mesenchyme assumes a definite attitude with reference to the nervous system in that many mesenchymal cells begin to make their way through the external limiting membrane into the neural tube. This wandering into the neuraxis of mesenchyme cells constitutes a veritable mesenchymal invasion. Cells of the mesenchyme, singly and in strings of two or three, make their way from the perineural mesenchyme into the neural ectoderm. These invading cells are not sprouts from the already formed endothelial spaces of the perineural mesenchyme. In many instances they proceed inward from regions in which neither blood islands nor isolated endothelial spaces are to be found. They may be seen either partially within the nervous system or their general course after entrance may be traced as strands extending toward the central canal. Coincident with this invasion there is a distinct advance in the perineural angiogenesis, for during this period the blood islands have given place to many isolated endothelial spaces, some of which have already become confluent with others in their immediate vicinity. Inasmuch as the outstanding feature at this time of development is the invasion of the neural tube by mesenchymal cells, this condition may be described as the *stage of mesenchymal invasion.*

Invasion of the tube by cells from the mesenchyme does not cease at the stage just mentioned, but continues until a much later period. Its fundamental importance in this early period lies in the fact that the neuraxis thus acquires the angiogenetic elements which serve as the

anlage for its vascular system. In embryos from 4 to 5.5 mm. in length the mesenchymal cells in the neural tube give evidence that the basofactive process is well under way. Numerous areas are observed which have all the appearances of the perineural blood islands, namely clusters of cells, some of which seem to be assuming endothelial characters while others, more central in position, present many features which ally them with the erythroblasts seen elsewhere. These latter cells are in many instances still attached to the mesenchymal clusters of which they form a part. In other areas the vasofactive process has advanced a step further and in consequence not a few isolated endothelial spaces containing free erythroblasts have made their appearance. The position occupied by the blood islands and isolated endothelial spaces within the neuraxis is noteworthy. At this time the neural ectoderm, in the myelencephalic region is eight to ten cells deep. The spaces and blood islands are situated near the central canal, being separated from it usually by two and never by more than three layers of cells. This position removes the spaces and blood islands within the neural tube as far as possible from the perineural endothelial spaces. The latter, by a process of confluence, have formed a well defined perineural plexus which, however, has no connection as yet with any of the endothelial spaces within the tube. The most conspicuous feature in embryos of this size is the inception of vascular formation within the neuraxis and the conditions may be described as the *stage of entoneural angiogenesis.*

In embryos from 6 to 7 mm. in length the number of entoneural endothelial spaces has increased and many of them have become confluent to form a relatively rich ento-neural plexus. As this plexus first takes form it presents no connection with the perineural plexus. Gradually, however, these two plexuses establish communication with each by the process of confluence. At first these communications are few in number but as the entoneural plexus increases in complexity the communications become more diffuse and more numerous until the period of full efflorescence in the vasofactive process is reached at 8.5 mm. when almost every section (cut at 5 μ) shows two or more connections between the perineural and entoneural plexuses. In embryos of 8.5 mm. the vasofactive process is at its height since the entoneural plexus is then more extensive, the size of its hemal channels larger and its connections with the perineural plexus more numerous than at any other period. From this time on the entoneural plexus gradually becomes reduced in richness as well as in the size of its channels.

In embryos from 9 to 24 mm. vascular formation passes into it by actual angiolysis. This latter process confines itself to the apparent excess of the early exuberant entoneural plexus. The prominent features of the angiolytic phase may be summarized as follows: (a) The partial solution of the rich entoneural plexus during which only the more radially disposed channels withstand the retrograde process and are thus selected to participate in the permanent vascular pattern, (b) the deflorescent channels revert to mesenchyme, (c) the deposition of such mesenchymal cells among the neural elements of the central nerv-

ous system and (d) the breaking down of many erythroblasts excluded from the circulation. From our observations we have drawn the following conclusions:

1. The development of the hemal channels of the central nervous system depends upon the formation of two separate plexuses, i.e., the perineural plexus and the entoneural plexus.
2. The perineural plexus is developed from the perineural mesenchyme first as a series of blood islands which give rise to isolated endothelial spaces, the latter in turn becoming confluent to form a plexus.
3. The entoneural plexus is developed from derivatives of the perineural mesenchyme, which, in the early stages, invade the neural tube, there giving rise to blood islands. From these blood islands are formed isolated endothelial spaces which become confluent to form a plexus.
4. The perineural and entoneural plexuses establish communication with each other by a process of confluence.
5. The entoneural plexus attains its highest development in the relatively early stages and then undergoes deflorescence. As a result of this latter process a considerable portion of the primitive vascular tissue within the neural tube reverts to mesenchyme cells which remain as constituents of the neuraxis.

67. On the pineal region in human embryos. JOHN WARREN, Harvard Medical School.

The object of this communication is to call attention to three special features in the development of the pineal region in human embryos.

1. The primary arches in the roof of the forebrain. In an embryo of 10 mm. all these arches are clearly differentiated. A low velum separates a well marked paraphysal arch from a relatively short and thick-walled post velar arch. The epiphysal arch is sharply defined with also rather thick walls and is succeeded by a relatively long pars intercalaris. This part of the brain roof forms a low arch in the posterior end of which the posterior commissure can be seen. The commissure seems to appear in this portion of the forebrain before invading the roof of the midbrain. In an embryo of 15 mm. the arches are more fully developed. A slight median thickening in the paraphysal arch marks the anlage of the paraphysis. The posterior commissure now occupies a larger part of the pars intercalaris and has developed backward into the midbrain. The primary arches as first described by Professor Minot in Acanthias can therefore be demonstrated in human embryos and in addition the pars intercalaris forms an arch of relatively great length as compared with its appearance in lower vertebrates.

2. Paraphysis. In the embryos of the Harvard Collection the earliest trace of the paraphysis can be noted as a slight thickening in the paraphysal arch in the embryo of 15 mm. mentioned above and in two others of 16 mm. No traces could be found however in any of the embryos of from 17 to 22 mm. with the possible exception of one of 19 mm. In an embryo of 23 mm. sagittal series it appears as a tiny

hollow elevation similar to its earliest form in lower vertebrates. In another embryo of 23 mm. transverse series it is a little larger and in one of 25 mm. it forms a good sized oval outgrowth with a cavity opening into that of the brain in front of the velum. Above this stage it could be demonstrated in an embryo of 31 mm. as a mere tiny elevation and also in one of 36 mm. where there was a slight cavity attached by a solid stalk to the brain wall. The oldest embryo in which any trace could be made out was one of 44.3 mm. where a tiny conical elevation in the paraphysal arch was all that could be seen. The paraphysis therefore does exist in certain human embryos but it is a rudimentary and inconstant structure. A short but well defined paraphysal arch could be followed in all the embryos studied.

3. Post velar arch. A complicated prolongation of the anterior end of this arch just behind the velum forms a striking feature in many embryos. This outgrowth appears either as a median projection or as a bilateral formation on either side of the median line coming into intimate relation with the vessels over the brain roof. As the outgrowth becomes more complicated, tubules are given off in a rather bewildering manner, which may become detached and appear as blind vesicles buried in the midst of this tubular formation. The paraphysis is more or less covered by this projection which overhangs to a large extent the paraphysal arch. The formation begins in embryos of 23 mm. as a simple median outgrowth. In an emryo of 25 mm. the outgrowth is a double one. In an embryo of 31 mm. two closed vesicles can be seen on either side of the middle arch, but still in contact with the brain wall. In an embryo of 36 and 44 mm. where the formation is extremely complex, one or more of these vesicles are found completely detached from the brain. Their walls are usually thinner than those of the other tubules among which they lie. Attention is called to this formation especially to the vesicular portion as it is such a striking feature in all the embryos from 23 mm. up to 44 mm.

68. Progressive movements in decerebrate kittens. Lewis H. Weed, Anatomical Laboratory, Johns Hopkins University.

In a series of forty kittens subjected to decerebration, different reactions of a rhythmic character were obtained. In all, an essentially similar ablation was performed with removal of cerebral hemispheres and basal ganglia. The brain-stem was cut through just anterior to the superior corpora quadrigemina, sloping forward in the line of the bony tentorium. The kittens continued to breathe spontaneously and as soon as the anesthesia had passed away, showed active reflexes and rhythmic progressive movements.

Differing from the reactions of adult animals, these decerebrate kittens did not exhibit an invariable extensor rigidity. All, however, gave typical scratch reflexes; they responded to both dorsal and ventral excitation, and reacted to trauma to the tail. In general the animals after decerebration were much more active than are the customary adult preparations. Practically all of these animals showed

rhythmic progressive movements; they seem to fall into two classes in this reaction, the groups being determined by the length of time the beats continued.

Twelve of these decerebrate kittens, on recovery from the anesthesia, showed, when suspended, typical prolonged walking movements of all four legs. These rhythmic progressive beats could be initiated by almost any stimulation and were continued for varying periods. In some of the animals the movements, after the initial excitation, were prolonged uninterruptedly until exhaustion occurred; in others the movements ceased after a few minutes. In the more active kittens, a smooth surface placed beneath the four feet of the animal occasioned continued progressive movements.

Separated from this group of kittens which showed prolonged rhythmic movements of progression are the other kittens of the series. These on appropriate excitation, made rhythmic movements lasting not over thirty seconds after the cessation of the stimulus. While the differentiation of the two groups is wholly arbitrary, the reactions of the animals are so different in this temporal relationship that the two classes seem indicated.

The reactions of the group of decerebrate kittens showing prolonged progressive beats are those of an adult cat in which only the cerebral hemispheres have been removed. The animals of the second group, however, are somewhat more active than are adult decerebrate cats. In the kittens of the first group, an extensor rigidity was absent in all but three; in these, a questionable rigidity occurred soon after the ablation and was quickly abolished by the onset of the rhythmic beats of all four legs. As the tendency to progression decreased, extensor rigidities became more pronounced, affecting in some only the forelegs. A reciprocal relationship between the prolonged progressive movements and the extensor rigidities has been indicated by these experiments.

The kittens which when decerebrated showed the phenomenon of prolonged progression varied in age from one hour to sixteen days (in length, from 150 to 220 mm.). Kittens of approximately the same age from the same litters in general gave similar reactions but considerable variation could be noticed. In any one litter, as the kittens grew older, the tendency toward prolonged progression grew less and the likelihood of extensor rigidities grew greater. Age alone, however, is, as judged by these observations, not an index of the reactions.

69. The coronary vessels of the heart of the 20-mm. pig embryo. (Lantern.) Thomas Foster Wheeldon, Harvard Medical School. (Introduced by Franklin P. Johnson.)

The present article is an extract from a larger paper entitled "The heart of the 20 mm. pig embryo." It is a study which was carried to completion at the University of Missouri under the direction of Professor Johnson.

Arteriae coronariae. As in the adult, the coronary arteries are two in number, a right and a left. They appear as small rounded vessels

with relatively thick walls. They spring from the superior aortic sinus and the left inferior aortic sinus respectively, and are distributed almost entirely to the heart, but a few small branches are given off to the roots of the great vessels.

The left coronary artery gives off a branch of particular interest which accompanies the atrio-ventricular bundle through the moderator band, and breaks up into capillaries in the right wall of the right ventricle.

Attention must be called, also, to a plexus to be found on the diaphragmatic surface of the heart. This plexus is formed by the anastomosis of the terminal branches of the right and left coronary arteries.

Sinus coronarius et venae cordis. Owing to the fact that the venal hemi-azygos of the pig opens into the coronary sinus, the relations of the entering cardiac veins are somewhat different from those found in man. There is, strictly speaking, no definite coronary sinus, for the cardiac veins all enter the terminal portion of the vena hemi-azygos. This portion of the vena hemi-azygos, which lies in the inferior portion of the coronary sulcus, is somewhat enlarged, and represents the coronary sinus of the human heart. In my description, I have used the term 'coronary sinus' to designate the terminal portion of the vena hemi-azygos.

The coronary sinus receives five large veins. They are from left to right; the vena hemi-azygos, the great cardiac vein, the inferior cardiac vein of the left ventricle, the middle cardiac vein, and the small cardiac vein. In addition, it receives the smaller anterior cardiac veins. It empties into the sinus venosus just ventral to the inferior vena cava. There is as yet no subdivision of the valve of the venous sinus to mark out the Thebesian valve, which in the adult pig guards the orifice of the coronary sinus.

The small cardiac vein, instead of arising as a single trunk as it does in the adult pig, arises as two definite vessels, one of which receives branches from the right atrium, while the other collects blood from the right wall of the right ventricle.

Little seems to have been published on the development or observation of the coronary vessels in embryos younger than 20 mm., and it was quite unexpected to find so complete a system in a pig of this size.

70. Study of a human spina bifida monster with encephaloceles and other abnormalities. THEODORA WHEELER, Carnegie Institute of Embryology, Baltimore.

The specimen was accompanied by only a meager clinical history; the child was illegitimate, was born spontaneously at full term, and lived only a few hours.

The external form is fairly typical of a class often called inencephalic monsters. There is extreme dorsal flexion and shortening of the trunk. The head is drawn back close to the sacral region. At the back of the head three encephaloceles project. The shoulders lie very high, pushed close to the cheeks. The neck is obliterated, the chin

and chest lying in one plane. The ears are distorted; the anthelix is pushed out so that it is very prominent; the tragus is shifted medially and upwards so that it lies opposite the concha; the antitragus lies below the tragus pushed against the cheek; the lobule is narrowed. These deformities are evidently caused by pressure on the external parts of the ear and twisting of these parts during their early development by the backward bent head and the shoulders which lie close to it on each side. In the region of the encephaloceles there is some normal scalp and also various cutaneous anomalies. On the lower border of the left sac there is a rounded bleb of porous, wrinkled skin, 1 cm. in diameter. A section through this region shows the bleb to lie over a funnel shaped canal which extends into the cerebro-spinal cavity. The covering of the central encephalocele is formed largely by a leather-like tissue. This consists of a very vascular connective tissue over the surface of which is a very thin layer of epidermis. There are numerous sweat glands in this region but no hair follicles. Near the tip of the sac there are two naevi; these consist of areas where the epidermis is lacking and the vascular tissue extends to the surface.

A sagittal section was made of the specimen. The central nervous system was removed and a wax model made of the cerebro-spinal cavity. The specimen was then dissected.

The skeleton shows marked maldevelopment. The arches of all the veretebrae are defective; they are open posteriorly and are flattened outwards. In the cervical and thoracic regions the bodies of the vertebrae are fused, shortened, and dorsally flexed, so that the spine is bent almost double. The occiput rests on the gaping vertebral arches and actually fuses with them on both sides. The lower two-thirds of the squamous portion of the occiput is defective. This forms a very large foramen magnum through which much of the brain has slipped. There is slight scoliosis of the vertebral plate. The lengths of the presacral vertebral parts are: cervical 15 mm.; thoracic 45 mm.; lumbar 43 mm. Comparing these with Acby's figures for average lengths of these parts in the normal newborn, cervical 45.1 mm.; thoracic 83.9 mm.; lumbar 47.5 mm., it is seen that while the lumbar portion of this specimen is of nearly normal length, its cervical portion is less than half, and its thoracic portion a trifle more than half that long. The vertebral bodies themselves have become somewhat widened. The ribs have undergone considerable disturbance. There are twelve ribs on each side. On the right the first six are fused near their origins; the second rib terminates at the end of its proximal third in a plate of bone joined to the first and third ribs. On the left the fifth to ninth ribs are crowded together in their proximal half; the fifth and sixth ribs have but one costal cartilage between them. The sternum is well formed. There are but six costal cartilage connections on each side. There is a persistent episternum. The two scapulae are defective along their vertebral margins. The left scapula is a much wider bone than the right owing to a prolongation of the medial extremity of the spinous process. This prolongation is joined to a rod of bone which in turn is attached

to the everted vertebral arches of that side. This stimulates a condition frequently associated with Sprengel's deformity, congenital elevation of the scapula. The cause of the hunched position of the shoulders, so prominent externally, shows clearly in the skeletal condition. The cervical and upper thoracic vertebrae lie crumpled to half their normal extent under the scapulae and completely change the normal relationships of these parts.

The following muscles have undergone disturbance. The trapezei are reduced to thin strap-like bands. The rhomboidei are shortened to 3 mm.; they arise from connective tissue over the everted arches of the thoracic vertebrae and are inserted in fascia along the inferior vertebral borders of the scapulae. The posterior superior serati could not be identified. The anterior serati are probably represented by scattered tissue on both thoracic walls. The sacro-spinalis and short back muscles lie as two separate muscle bundles, one on each side of the everted vertebral arches.

The soft palate is not formed. There is a bilateral anlage of the uvula on the sides of the pharynx. The right lung is formed of but one lobe.

The central nervous system is very much distorted. The three encephaloceles lie below the foramen magnum. There is considerable cerebral tissue in the left and middle encephaloceles while the one on the right side contains cerebellar tissue. At the base of the brain, of which a large part has slipped below the foramen magnum onto the thoracic vertebrae, the cranial nerves can all be identified; they are much elongated. Owing to a Z-shaped bend of the cord and brain stem the fourth ventricle has been completely inverted and lies on top of the spinal cord. From the floor of the fourth ventricle some cerebellar tissue is drawn back as a flattened sheet to join the rest of the cerebellar tissue in the right encephalocele. The spinal nerves though much crowded are all present, emerging from a flat spinal cord.

71. Variations in the wall and epithelium of the stomach and esophagus in normal distention. (Lantern.) H. O. White, Anatomical Laboratory of the College of Physicians and Surgeons, University of Southern California, Los Angeles.

From observations and comparisons derived in the laboratory course of normal histology during the least few semesters, it appeared that the marked changes evident in the musculature and epithelium of the stomach and esophagus merit detailed investigation. To accomplish this the stomach and esophagus of two freshly killed cats were utilized in the normally distended and collapsed conditions. In order to fix the organs in a state of approximately normal distention, saturated aqueous solution of mercuric chlorid was injected into them, and after securely ligating to prevent the outflow of the fluid, were immersed in the same solution for further fixation. Longitudinal and transverse frozen sections from the contracted and distended organs were made, after proper washing in running water and subsequently in iodized

70 per cent alcohol. Details of histological variations were best obtained by staining the sections with hematoxylin and Picro-acid-fuchsin. Preference was given to the latter stain due to its brilliancy with which it brings out muscle and fibrous tissue. The following results were obtained after measurements taken in micra.

Under the same pressure, the esophageal wall in nearly normal contraction and distention, shows a greater decrease in thickness than that of both parts of the stomach wall under the same conditions.

Comparing the limit of distensibility of the stomach and oesophageal walls, under the same pressure, I found that it is more definite in the latter than in the former, due in all probabilities to the greater amount of supporting and muscle tissue, and also to the varied directions of distribution of the muscle layers of the stomach. In the mucous coat the papillae-like projections of the tunica propria, or corium upon which the epithelium of the esophagus rests are, in consequence of normal distention entirely obliterated, to such an extent that the tunic represents a smooth layer of areolar tissue supporting an equally smooth layer of stratified epithelium, and the tunic is markedly reduced in thickness. The tunica propria of the normally distended stomach, though very appreciably reduced in thickness, does not lose its characteristic appearance, due undoubtedly to the greater abundance of areolar tissue in that tunic and also to the greater folding of the entire mucosa of the stomach.

While in the contracted state only the innermost cells of the epithelium of the esophagus are flattened, and the flatness gradually changing as the middle layers are approached until finally the outermost layer of cells is rather of a simple columnar shape and the nuclei round or oval, in the normally distended esophagus, not only the familiar shape of the entire epithelium changes, but is also much reduced in thickness, every cell is flattened out and hence elongated; the nuclei in consequence assuming a distinct spindle-shaped appearance.

May not this diminution of the epithelium in thickness (about 65 per cent) together with the flattening of the cells in consequence of normal distention possibly suggest an actual gliding of one cell upon the other, and hence a displacement to some extent? As to the epithelium of the stomach, while the entire mucosa is reduced in thickness (about 40 per cent) in normal distention under the same pressure as in the esophagus, the epithelium itself is only slightly compressed, due probably to the fact that the tunica propria, normally prolonged into the lumen of the stomach above the gastric glands supporting the single layer of columnar epithelium, forms projections of considerable length and these, during normal distention, become imbricated, thereby preventing material changes in the epithelium of the viscus.

The musculature of normally distended stomach and esophagus share relatively an equal reduction in thickness, the longitudinally disposed muscle layers, however, participating more in the thinning process than the circular layers, due evidently to the fact that normally the former is much thinner than the latter. On the other hand,

since the muscularis mucosa of the esophagus normally does not form a complete continuous layer, hence the fasciculi of this tunic, in normal distention, become widely separated, while the same tunic of the stomach, because of its continuity as a complete layer from one end of the stomach to the other, is only appreciable reduced in thickness (about 15 per cent) under identical conditions.

*72. *Some peripheral relations in the cranial nerves of reptiles.* WILLIAM A. WILLARD, Department of Anatomy, University of Nebraska, College of Medicine.

This paper deals with the peripheral distribution of the preauditory cranial nerves of the common garter snake, Eutania sirtalis, with some comparisons with the same region in the lizard, Anolis carolinensis, which has previously been described. The points presented represent a partial report on the study of the Ophidian head which embraces all the cranial nerves with the attempt to analyze them into their functional components. While the following descriptive account is inclusive of the main points only, it is based upon a detailed study of two excellent series of sections, one of a full grown specimen the other of a young snake about six inches in length. The only noticeable difference was one in myelination and this was so slight that it may be due to technique instead of difference in age.

The nerves to the muscles of the eyeball are well developed and their superficial origin from the brain corresponds to the condition found elsewhere. Their course to the orbit is intracranial. They converge to unite with each other and with the ophthlamic branch of the trigeminal. The identity of the IV nerve is preserved in section although included in the same sheath with the others. That of III and VI is entirely lost in V for a short part of the course. At the level of the posterior side of the orbit this common trunk again resolves itself into its component parts, VI and part of III first separating from the dorsal side of the trunk to innervate the posterior and inferior rectus muscles respectively. The remainder of III still closely applied to the ventral side of V is marked by the deeper impregnation of its fibers. As this part separates from the ophthalmic the short root of the ciliary nerve is given off from the latter. A segregation of unmyelinated and very lightly myelinated fibers which make up this root is observable in the ophthalmic portion of the common trunk before III separates from it. No direct contribution of fiber from III is recognized either before or after its separation from V. The ciliary root passes at once into the small cilary ganglion from which a single cilary nerve passes into the eyeball. The muscles of the orbit are limited to the four recti and two oblique, there being no accessory muscles. The six muscles are innervated in the usual manner.

The trigeminal nerve is represented in the snake by two anatomically distinct nerves. The ophthalmic nerve has a course cephalad within the bony and membranous cranium to a point opposite the middle of the orbit where it gives off a ramus frontalis to the interorbital integ-

ument while the remainder of the nerve as the ramus nasalis after its separation from III and VI, and from the ciliary root has the same distribution as in Anolis to the epithelium of the nasal capsules and the integument of the preorbital region. It sends no fibers to the mucous membrane of the mouth. The ophthalmic ganglion is large and its root enters the brain just cephalad to the roots of the maxillo-mandibular division of the trigeminal. The maxillo-mandibular division of the Gasserian ganglion is relatively about twice the size of the same structure in the lizard and the nerves entering the ganglion correspondingly large. The maxillary ramus is formed by the union of an infraorbital and a superior labial branch. The first innervates the integument covering the superior labial glands, the second, in combination with the palatine branch of VII is limited to the mucous membrane of the palatine and maxillary regions of the mouth.

The mandibular ramus after giving off nearly all of its motor fibers to the muscles of the head, passes into the bony mandible. In its cephalad course it divides its fibers in a manner similar to that of the maxillary ramus, between the integument and the mucous membrane of the mouth. In addition a large lingual branch takes a recurrent course to reach the base of the long tongue sheath. With this lingual division an extremely fine chorda-tympani nerve unites.

The geniculate ganglion and the facial nerve when separated from the trigeminal, as is only possible by means of sections, present about the same condition as that found in Anolis. The two component roots are distinguishable within the brain. They leave the cranium through a special foramen, which is covered externally by the manibular wing of the Gasserian ganglion. This results in the fusion of the geniculate with the latter ganglion, although its limits are clearly marked in the sections. From the geniculate ganglion a fine fibered palatine ramus passes cephalad intracranially, and a mixed fine and coarse fibered hyomandibular ramus passes caudad. The palatine ramus does not give off any branches until after it has been united anterior to the orbit by means of sympathetic ganglia with the median or infraorbital branch of the V, and there seems to be evidence in the large number of unmyelinated fibers which it contains that it represents, in part, a sympathetic pathway between these ganglia and the brain. The hyomandibular ramus gives off nearly all its fine fibers, most of which are not myelinated to form a communicating ramus with the lower sympathetic ganglia. This ramus is not joined as in the lizards by an external communicating ramus from the orbital plexus. The few remaining fine fibers in the hyomandibular ramus are given off some distance caudad. This extremely small ramus enters the lower jaw and eventually joins the lingual branch of the mandibular ramus of the V. It has been termed the chorda-tympani on the basis of its course and connections, although it has the appearance of a fine unmyelinated sympathetic ramus. There is no middle ear chamber here to modify its course as a post-trematic branch and its position is relatively farther caudad than in the lizard.

The groups of sympathetic ganglion cells which in other reptiles have been included under the terms, palatine, infraorbital, ethmoidal and mandibular ganglia are recognized in the snake in increased degree and in addition other ganglia are found not appearing in the lizard. The ciliary ganglion and nerve are smaller owing to the less specialized development of the eye.

The cutaneous sense organs are dermal corpuscles projecting into the epidermis. These are very abundant along the jaws. Special epithelial sense buds are found in the mouth along the palatine and maxillary and mandibular dental areas. These have the appearance of taste buds but their undoubted innervation by fibers carried in the branches of the trigeminal nerve suggests the possibility of a tactile function. Further study may disclose different types of sense organs in the mouth.

*73. *A new method for the study of the development of the lymphatic system.* G. B. Wislocki, Department of Anatomy, Johns Hopkins University.

A clear idea of the origin and growth of the lymphatic system was first obtained by Sabin, who combined the study of sections of embryos with the injection of the lymphatics with india-ink. This conception comprises the fundamental truths, that the first lymphatics arise by budding from the veins, that the lymph-channels grow from center to periphery (the theory of lymphatic and non-lymphatic zones) and lastly, that the lymphatic capillaries are closed channels lined by endothelium which grow by sprouting and budding. The theory of the venous origin of the lymphatic system is in direct accord with the earlier work upon the development of blood-vessels by His, Hoyer, Prévost, Rouget and Mall and with the work upon the nature of lymphatics by von Recklinghausen and upon their growth by Ranvier.

Schwann's discovery of the vascular channels in the tadpole's tail made possible the first studies of living growing vessels, and since his time the tails of amphibian larvae have been studied again and again in hope of solving the questions of the mode of growth of lymphatics. The difficulty of this method of studying the growth of lymphatic vessels is shown by the diversity of the views to which such a study has led different observers, and it was not until Clark devised an anaesthetizing chamber that accurate and useful observations could be made. He was able to show definitely that lymphatic vessels grow by sprouting, and not by the addition to them of changed blood-vesselsor tissue-spaces or the transformation of mesenchymal cells into endothelium, and his observations tend to support the argument for the venous origin of the lymphatics system.

In spite of the enormous amount of evidence in its favor, there are many who are unwilling to accept the theory of the venous origin of lymphatics as outlined by Sabin and her co-workers. It seems pertinent therefore at this time to report briefly and present a few of the results of a new technique for studying the growth of lymphatics,

which, combined with the Clark method and the study of sectioned material promises to throw additional light upon the growth and origin of lymphatics.

The method consists in vitally staining amphibian larvae and observing the lymphatics, whose endothelium stains quite specifically intra vitam with acid azo-dyes, by means of a Clark chamber and in sections.

Frog eggs were collected and brought into the laboratory, where they were hatched and the larvae kept in aquaria until used. Initially Rana temporaria, Rana catesbiana, Hyla pickeringii and a species of Amblystoma were employed and although similar results were obtained with all the species, the two former are now used exclusively because they have proven more satisfactory. The larvae were transferred a few at a time, at short intervals after hatching, to finger-bowls containing solutions of trypan-blue (the most easily obtainable diazo body) in ordinary tap-water, ranging in strength from 1 : 600 to 1 : 1000. The animals were kept in solutions of trypan-blue of these strengths for many weeks without noticeable impairment of their vitality. The details of the preliminary trials are omitted here for brevity.

The tadpoles were examined daily under the microscope in a Clark chamber for the appearance of the dye in the tail. The first trace of dye in the larvae were noticed about the fourth or fifth day, the amount rapidly increasing. From the time of its first appearance it was evident that the aggregates of coloring-matter occurred within the living endothelium of the lymphatic vessels, and by the end of ten days the stain had accumulated to such an extent, that the entire lymphatic system was brilliantly outlined in blue. The dye stained the lymphatic endothelium only, for there was no trace of blue in the endothelium of the blood-vessels, or in the circulating blood-elements, nor did the mesenchyme cells or wandering cells apparently phagocytise any of the color. There would seem to be a specific ability on the part of embryonic lymphatic endothelium to ingest dispersions of vital dyes, a specificity which furnishes us a means of distinguishing accurately lymphatic endothelium from mesenchyme or venous endothelium. Attempts to differentiate lymphatic endothelium from mesenchyme have been made before by Clark, in chick embryos, and by Kampmeier in the toad, but their criteria for differentiating the two tissues are not widely applicable and therefore are not of great practical value.

Sections of the stained animals show that the lymphatic system in its entirety had absorbed the dye, and that, as in the tail, vascular endothelium, mesenchyme cells and blood-elements were everywhere unstained. The only other tissues which seemed to store the dye in appreciable amounts was the liver, the 'Kupffer cells to a marked degree, the liver parenchyma to a lesser degree. Occasionally the trypan-blue was observed in groups of pyrrhol-cells occurring in the mesentery, this however was by no means constant.

The absorption and excretion phases of vital staining in these larvae the author discusses in another paper. From the diffuse blue staining of

the intestinal tract it would seem most likely that absorption occurred in that region, as there is no evidence at present pointing to the epidermis or gills as a portal of entry. Excretion of the dye by the kidney-tubules and through the mucosa of the gill-arches was demonstrable.

In the living tadpole's tail, in a Clark chamber under the oil-immersion lens, the nuclear areas in the lymphatic-walls were seen to be free from stain, the dye-granules corresponding in distribution to the granular zone of the cytoplasm and extending some distance into the cytoplasmic filaments and pseudopods. The growing lymphatics were readily studied, as the lymphatic endothelium was distinguishable at all times, owing to its characteristic stain, from mesenchyme cells or vascular endothelium. The observations of Clark on the mode of growth and nature of lymphatic sprouts and tips have been repeated and verified by this method. It is to be hoped that the method will further lend itself to the solution of the problem of the growth of the thoracic duct in amphibian larvae.

DEMONSTRATIONS

1. *The cellular changes in the prostate gland of the albino rat after castration.* W. H. F. Addison and R. D. Spencer, University of Pennsylvania.

2. *The origin and fate of the osteoclasts. Microscopic preparations and illustrations in color showing how osteoclasts arise from osteoblastic synticia, grow by incorporating osteoblasts and bone cells, and, in part, ultimately degenerate.* L. B. Arey, Northwestern, University Medical School.

3. *The 'ultimobranchial bodies' in various developmental stages of pig embryos.* J. A. Badertscher, Indiana University School of Medicine.

4. *Studies of the cortex of the sheep brain.* Charles Bagley, Jr., Phipps Psychiatric Clinic, Johns Hopkins University.

5. *Sections of folded or U-shaped embryos.* W. M. Baldwin, Albany Medical College, Union University.

6. *Dissectible blotting paper models of various stages of development of the forebrain of Amia.* Charles Brookover, University of Arkansas Medical Department, Little Rock.

7. *1, Models illustrating the development of the mammalian heart. 2, Models illustrating the development of the mammalian vertebrae in the membranous and cartilaginous stages.* Alfred J. Brown, Anatomical Laboratory, Columbia University.

8. *Histological differences between certain muscles of the cat.* H. Hays Bullard, Johns Hopkins Medical School.

9. Models of the brain of normal and operated Amblystoma larvae to show the morphogenesis of the lateral hemispheres. H. Saxton Burr, Yale University School of Medicine, New Haven.

The models here demonstrated were made from sections of normal Amblystoma larvae, using with one exception blotting paper instead of wax plates. The models show briefly that in the morphogenesis of the lateral hemisphere the following steps occur:

In the first place the lateral wall of the cephalic end of the neural tube becomes greatly thickened. An increase in area of this thickened portion brings about an infolding of the anterior wall in the region just dorsal to the paraphysis thus forming the first sign of the velum transversum. A continued growth results in the folding out laterally of the superior margin of the thickened area. At first this folding is most prominent dorso-laterally but soon the evagination progresses not only dorso-laterally but anteriorly beyond the limits of the original neural tube. In this manner is formed the primitive lateral ventricle which is connected with the cavity of the neural tube by the wide open interventricular foramen. We have formed thus a lateral hemisphere whose outer wall consists of a much thickened ovoid mass connected to the neural tube by a thin lamina of neurogenic tissue.

Concomitant with the in-growth of the olfactory nerve from the nasal placode, the medial wall of the ventricle begins to increase in thickness, progressing posteriorly from the anterior pole. At the same time the thin layer of tissue connecting the dorso lateral portion of the hemisphere with the neural tube is in turn thickened until there is formed a hemisphere essentially like the adult, consisting of a ventro-lateral ovoid mass, the corpus striatum, a superior curved lamina, the primitive pallium, and a medial thickened wall.

One model shows a stage in the regeneration of the lateral hemisphere which had been removed by an operation which left the nasal placode in place. It is interesting to note here that the regenerating hemisphere passes through essentially the same course of development as has been described above for the normal.

10. The innervation of the vertebrate digestive tube (methylene blue intravitam staining). F. W. Carpenter, Trinity College, Hartford.

11. Lipoid structures appearing in the corpus luteum cells of swine after fixation with aqueous solutions. George W. Corner, Hearst Anatomical Laboratory, University of California.

12. Haemotopoieses in the yolk sac of birds. Vera Danchakoff and Clayton Sharp, Columbia University.

13. Lymphoid hemoblasts of the adult spleen. Vera Danchakoff, Columbia University.

14. Intra vitam staining with the acid colloidal dye pyrrolblau:

1. Sections of doubly ligatured femoral vein of rat showing polymorphonuclears and lymphocytes with the 'dye granules.'
2. Sections of tissue at the site of intramuscular injection, showing polymorphonuclears and lymphocytes containing the dye granules. HAL DOWNEY, Department of Animal Biology, University of Minnesota.

15. Chondriosomes in fish embryos. J. DUESBERG, Carnegie Institution, Department of Embryology, Baltimore.

Sections of embryos of Fundulus heteroclitus and Morone americana (white perch). The embryos were fixed with Bendas or Regaud's fluid, the sections stained with iron-hematoxylin or Bensley's fuchsin S-methylgreen. Chondriosomes, either in form of granules or of filaments, are present in the cells of all tissues.

16. Further preparations showing the effect of vital stains on the cells of the corpus luteum, the theca folliculi, the granulosa, and the zona pellucida of the mammalian ovum. HERBERT M. EVANS, University of California.

17. A laboratory aid for the study of neuro-anatomy. J. H. GLOBUS, Cornell Medical School, New York City.

A series of sketches, outlines and diagrams of the more important structures of the brain and spinal cord are incorporated in the form of a semi-completed atlas and used in the course of neuro anatomy at Cornell Medical School.

The sketches are made from carefully dissected specimens and bring into view the more important gross structures of the central nervous system. The task of labeling such structures, however, is left to the student who is, thus, required to make careful observations in order that he may label the drawing correctly.

The outlines are drawn by the aid of the projectoscope from selected transverse and longitudinal sections of the brain stem and spinal cord. The enlargement is uniform throughout and only the larger and rather easily identified structures are included in the outlines. The student from the section under his observations draws in the more minute and less evident structures. Here again the task of labeling is left to him, which demands a careful study of the given section in order to identify and label structures correctly.

A limited number of diagrams are added. They enable the student to plot certain long tracts as he traces them through the various levels of the spinal cord and brain stem. Thus a daily record is obtained of the course taken by tracts studied, and in the end isolated facts are brought together.

The first drawing of the series is completely filled in and labeled and serves as a model for putting in details in the remaining outlines. The

nuclei of gray matter are represented by groups of irregular triangles in red and the tracts by black dots of uniform size where fibers are cut transversely and black lines of variable thickness if they are cut longitudinally. The labeling is done by subdued lettering and lines.

At the end of the course the student will have a collection of correct drawings illustrating the more important structures of the central nervous system.

18. Microscopic preparations of endothelium and wandering connective tissue cells as seat of origin of hemoglobin. J. H. GLOBUS, Cornell Medical School.

19. Microscopical preparations showing various phases of excretory function in selachians. E. R. HOSKINS and MARGARET MORRIS, New York and Yale Universities.

20. Casts of eleven gorilla brains. A. HRDLIČKA, Smithsonian Institution.

21. Genetic factors leading to the development of mammalian pulmonary asymmetry. Sections, corrosions and reconstructions. GEO. S. HUNTINGTON, Columbia University.

22. Effects of inanition upon the structure of the hypophysis in the albino rat. C. M. JACKSON, Institute of Anatomy, University of Minnesota.

23. Specimens showing the later development of the lobules of the pig's liver. FRANKLIN P. JOHNSON, University of Missouri.

24. Methods of mounting sections in gelatine. J. B. JOHNSTON, University of Minnesota.

25. Microscopic preparations of mongoose, pig and turtle embryos, to show endothelial hemoblasts and aortic cell clusters. H. E. JORDAN, University of Virginia.

26. A demonstration of the sense cells of the retina, olfactory mucous membrane and taste-buds. H. M. KINGERY, Cornell University Medical College, Ithaca.

The method of making these preparations is similar to that employed in obtaining a Weigert copper hematoxylin preparation. The tissue was fixed in copper-dichromate-sublimate-acetic mixture and afterwards mordanted for four to six days in copper dichromate solution. Weigert's copper hematoxylin stain was used on paraffin sections. The method seems to pick out the sense cells specifically, perhaps due to their reducing action of the dichromate in solution.

27. A simple method of brain dissection. P. E. LINEBACK, Atlanta Medical College, Emory University.

28. Preparations of vitally stained bone and pathological calcareous deposits. C. C. Macklin, Johns Hopkins Medical School, and the Wistar Institute of Anatomy and Biology.

29. Radiograph prints of mesial sections of horse heads and also prints of limbs. H. S. Murphey and J. D. Grossman (introduced by C. R. Stockard), Department of Veterinary Anatomy, Iowa State College, Ames.

1. 280 day fetus; 2. 308 day fetus; 3. 340 day fetus (end of term); 4. 7 month foal; 5. 23 months; 6. 4 years 10 months; 7. 16 years old; 8. Old horse injected naso-lacrimal duct; parotid duct and infraorbital canal wired. 9. Vessels injected; 10. 'Poll' from above; 11. Miscellaneous views from above heads with shot in the sinuses.

1. Lateral cartilage of the third phalanx, covered by tinfoil to show extent; 2. Mesial section of metacarpus and digit; to show extent of bursae, vaginal sheathes and joint capsules marked by lead glass; 3. Lateral view of injected vessels of digits from thoracic and pelvic limbs; 4. Anterior and posterior views of No. 3; 5. Injected digital synovial sheath; 6. Lateral view of carpus; 7. Lateral view of carpus mesial section showing extent of bursae, vaginal sheathes and joint capsules; 8. Lateral view of carpus and tarsus vessels injected; 9. Anterior view of No. 8; 10. Lateral view of tarsus showing injection of synovial sheath of long extensor of digit; 11. Injected stifle (knee) joint.

C, Maceration specimen of skin at border of hoof.

30. Development of primitive cardiac loop in the rabbit with special reference to the bulbo-ventricular cleft and the origin of the interventricular septum. Models and slides. H. A. Murray, Jr. (introduced by H. von W. Schulte), Columbia University.

31. Modeling embryos on glass plates. H. Muryama (introduced by C. R. Stockard,) Cornell Medical School, New York City.

32. Wax reconstructions and stained preparations illustrating the fetal development of the mammary gland in the albino rat. J. A. Myers, Institute of Anatomy, University of Minnesota.

33. Demonstration of models illustrating the morphogenesis of the human thyroid follicle. 2. Demonstration of models illustrating the early morphogenesis of the thyroid gland in squalus acanthias. E. H. Norris (introduced by C. M. Jackson), Institute of Anatomy, University of Minnesota.

34. Microscopic preparations showing various stages in the developmental changes of the idiosome. George N. Papanicolaou, Cornell Medical School, New York City.

35. Specimens illustrating the histology of proœstrous and ovulation in the guinea-pig. GEORGE N. PAPANICOLAOU, Cornell Medical School, New York City.

36. Sections and dissections of the notochord of an East Indian scorpion. WILLIAM PATTEN, Dartmouth College.

37. Models of the urogenital tract of the 20 mm. pig embryo. FRANK H. ROSE (introduced by Franklin P. Johnson), Harvard Medical School.

38. On the development of the first head-vein and its relation to the so-called vena capitis media and vena capitis lateralis. FLORENCE R. SABIN, Anatomical Department, Johns Hopkins University.

39. The early stages of the development of the great veins and of the hepatic circulation in the cat. Models and slides. H. VON W. SCHULTE, Columbia University.

40. Reconstructions showing developing nerves and arteries in the lower extremity, man and pig. H. D. SENIOR, University and Bellevue Hospital Medical College.

41. Specimens of hypophysectomized and control tadpoles (Rana boylei). P. E. SMITH, University of California.

42. The intracentral course of efferent cranial nerve roots traced by the method of indirect Wallerian degeneration. SUTHERLAND SIMPSON, Cornell University Medical College, Ithaca.

43. Breeding cages, inhalation cages and tanks, and a colony of mammals having been experimentally used for different periods up to six years in a study of the production and inheritance of morphological abnormalities. C. R. STOCKARD, Cornell Medical School, New York City.

44. Drawings illustrating the anatomy of the albatross. R. M. STRONG, Anatomical Laboratories, Vanderbilt University Medical School.

45. Preparations showing the mitochondrial content of the cells of the nuclei of the cranial nerves of the albino rat. MADGE DE G. THURLOW, Johns Hopkins University and the Wistar Institute of Anatomy (introduced by E. V. Cowdry).

46. 1. The generating substratum of the 'Membrana tectoria' represented by the crista spiralis and the epithelial ridges. 2. Genesis of the teeth of Huschke. 3. The teeth of Huschke in the adult organ. 4. Stages of development of the membrana reticularis at the surface of the auditory epithelium: Crista and Macula Acoustica and organ of corti. O. VAN DER STRICHT (by invitation), Western Reserve University.

47. Models of the roof of the fore brain in early human embryos. JOHN WARREN, Harvard Medical School.

48. Models of the coronary vessels in the pig embryo. T. F. WHEELDON (introduced by F. P. Johnson,) Harvard Medical School.

49. (1) *Dissection and drawings of a human trunk showing situs totalis viscerum inversus;* (2) *Drawings and lantern slides from a dissection showing anomalous origin of* (a) *Arteria Gastrica Sinistra,* (b) *Arteria Mesenterica Superior, and* (c) *Arteria Spermaticae Internae in the same cadaver;* (3) *Drawing and lantern slides from a dissection showing* (a) *anomalous origin of Arteria Lienalis,* (b) *absence of Arteria Coeliaca,* (c) *anomalous origin of Arteria Gastrica Dextra, Arteria Gastrica Sinistra, Arteria Hepatica, in the same cadaver.* H. O. WHITE, Anatomical Laboratory of the College of Physicians and Surgeons, University of Southern California.

50. Models of the heart and digestive tract in the 12 day 18 hour, and the 14 day albino rat embryos. CHESTER H. HEUSER, The Wistar Institute.

CONSTITUTION

Article I

Section 1. The name of the Society shall be "The American Association of Anatomists."

Sec. 2. The purpose of the Association shall be the advancement of anatomical science.

Article II

Section 1. The officers of the Association shall consist of a President, a Vice-President, and a Secretary, who shall also act as Treasurer. The President and the Vice-President shall be elected for two years, the Secretary for four years. In case of absence of the President and Vice-President, the senior member of the Executive Committee shall preside. The election of all the officers shall be by ballot at the annual meeting of the Association and their official term shall commence with the close of the annual meeting.

Sec. 2. At the annual meeting next preceding an election, the President shall name a nominating committee of three members. This committee shall make its nominations to the Secretary not less than two months before the annual meeting at which the election is to take place. It shall be the duty of the Secretary to mail the list to all members of the Association at least one month before the annual meeting. Additional names for any office may be made in writing to the Secretary by any five members at any time previous to balloting.

Article III

The management of the affairs of the Association shall be delegated to an Executive Committee, consisting of eleven members, including the officers. Two members of the Executive Committee shall be elected annually and, so far as possible, election of members of the Executive Committee shall be in proportion to the geographical distribution of members. Five shall constitute a quorum of the Executive Committee.

Article IV

The Association shall meet at least annually, the time and place to be determined by the Executive Committee. The annual meeting for the election of officers shall be the meeting of convocation week, or in case this is not held, the first meeting after the new year.

Article V

Section 1. Candidates for membership must be persons engaged in the investigation of anatomical or cognate sciences, and shall be proposed in writing to the Executive Committee by two members, who shall accompany the recom-

mendation by a list of the candidate's publications, together with references. Their election by the Executive Committee, to be effective, shall be ratified by the Association in open meeting.

Sec. 2. Honorary members may be elected from those who have distinguished themselves in anatomical research. Nominations by the Executive Committee must be unanimous and their proposal with a reason for recommendations shall be presented to the Association at an annual meeting, a three-fourths vote of members present being necessary for an election.

Article VI

The annual dues shall be seven dollars. A member in arrears for dues for two years shall be dropped by the Secretary at the next meeting of the Association, but may be reinstated at the discretion of the Executive Committee on payment of arrears.

Article VII

Section 1. Twenty members shall constitute a quorum for the transaction of business.

Sec. 2. Any change in the constitution of the Association must be presented in writing at one annual meeting in order to receive consideration and be acted upon at the next annual meeting; due notice of the proposed change to be sent to each member at least one month in advance of the meeting at which such action is to be taken.

Sec. 3. The ruling of the Chairman shall be in accordance with "Robert's Rules of Order."

The orders adopted by this Association, which read as follows, have not been altered:

Newly elected members must qualify by payment of dues for one year within thirty days after election.

The maximum limit of time for the reading of papers shall be fifteen minutes.

The Secretary and Treasurer shall be allowed his traveling expenses and the sum of $10 toward the payment of his hotel bill, at each session of the Association.

That the Association discontinue the separate publication of its proceedings and that the Anatomical Record be sent to each member of the Association, on payment of the Annual Dues, this journal to publish the proceedings of the Association.

AMERICAN ASSOCIATION OF ANATOMISTS

OFFICERS AND LIST OF MEMBERS

Officers

President.....Henry H. Donaldson
Vice-President.....Clarence M. Jackson
Secretary-Treasurer.....Charles R. Stockard

Executive Committee

For term expiring 1917.....Warren H. Lewis, C. Judson Herrick
For term expiring 1918.....Hermann von W. Schultz, John L. Bremer
For term expiring 1919.....Eliot R. Clark, Reuben M. Strong
For term expiring 1920.....Franklin P. Mall, J. Playfair McMurrich

Committee on International Congress

F. P. Mall and G. S. Huntington

Committee on Nominations for 1917

J. P. McMurrich, Chairman, J. C. Huber, and G. A. Piersol

Honorary Members

S. Ramón y Cajal.....*Madrid, Spain*
John Cleland.....*Glasgow, Scotland*
Camillo Golgi.....*Pavia, Italy*
Oscar Hertwig.....*Berlin, Germany*
Alexander Macalister.....*Cambridge, England*
A. Nicolas.....*Paris, France*
L. Ranvier.....*Paris, France*
Gustav Retzius.....*Stockholm, Sweden*
Wilhelm Roux.....*Halle, Germany*
Carl Toldt.....*Vienna, Austria*
Wilhelm Waldeyer.....*Berlin, Germany*

Members

Addison, William Henry Fitzgerald, B.A., M.B., Assistant Professor of Normal Histology and Embryology, University of Pennsylvania, *3932 Pine Street, Philadelphia, Pa.*

Allen, Bennet Mills, Ph.D., Professor of Zoölogy, University of Kansas, *1653 Indiana Street, Lawrence, Kans.*

Allen, Ezra, A.M., Ph.D., Professor of Biology, *Philadelphia School of Pedagogy, 125 Thompson Ave., Ardmore, Pa.*

Allen, William F., A.M., Ph.D., Professor of Anatomy, *University of Oregon Medical School, Portland, Oregon.*

Allis, Edward Phelps, Jr., LL.D., *Palais de Carnoles, Mentone, France.*

Amsbaugh, A. E., A.B., Student of Medicine, *University of California, Berkeley, Calif.*

Arey, Leslie B., Ph.D., Instructor in Anatomy, Northwestern University Medical School, *2421 Dearborn Street, Chicago, Ill.*

Atwell, Wayne Jason, A.B., A.M., Instructor in Anatomy, University of Michigan, *617 Whaley Court, Ann Arbor, Michigan.*

Bagley, Jr., Charles, M.D., Phipps Institute, *Johns Hopkins Hospital, Baltimore, Md.*

Bailey, Percival, B.S., Assistant in Anatomy, *Northwestern University Medical School, Chicago, Ill.*

Baitsell, George Alfred, Ph.D., Instructor in Biology, *Yale University, New Haven, Conn.*

Baker, Frank, M.D., Ph.D., LL.D. (Vice-Pres. '88–'91, Pres. '96–'97), Professor of Anatomy, Medical Department, University of Georgetown, *1901 Biltmore Street. Washington, D. C.*

Baldwin, Wesley Manning, A.M., M.D., Professor of Anatomy, *Albany Medical College, Albany, N. Y.*

Bardeen, Charles Russell, A.B., M.D. (Ex. Com. '06–'09), Professor of Anatomy and Dean of Medical School, *University of Wisconsin, Science Hall, Madison, Wis.*

Badertscher, Jacob A., Ph.M., Ph.D., Assistant Professor of Anatomy, Indiana University School of Medicine, *312 S. Fess Ave., Bloomington, Ind.*

Bartelmez, George W., Ph.D., Assistant Professor of Anatomy, *University of Chicago, Chicago, Ill.*

Bates, George Andrew, M.S., D.M.D., Professor of Histology and Embryology, *Tufts College Medical School, Boston, Mass.*

Baumgartner, Edwin A., Ph.D., Associate in Anatomy, *Washington University Medical School, St. Louis, Mo.*

Baumgartner, William J., A.M., Assistant Professor of Histology and Zoölogy, *University of Kansas, Lawrence, Kans.*

Bayon, Henry, B.A., M.D., Associate Professor of Anatomy, Tulane University, *2212 Napoleon Avenue, New Orleans, La.*

Bean, Robert Bennett, B.S., M.D., Professor of Anatomy, *University of Virginia, University, Virginia.*

Begg, Alexander S., M.D., Instructor in Comparative Anatomy, *Harvard Medical School, Boston, Mass.*

Bensley, Robert Russell, A.B., M.B. (Second Vice-Pres. '06–'07, Ex. Com. '08–'12), Professor of Anatomy, *University of Chicago, Chicago, Ill.*

Bevan, Arthur Dean, M.D. (Ex. Com. '96–'98), Professor of Surgery, University of Chicago, *2917 Michigan Avenue, Chicago, Ill.*

Bigelow, Robert P., Ph.D., Associate Professor of Zoölogy and Parasitology, *Massachusetts Institute of Technology, Boston, Mass.*

Black, Davidson, B.A., M.B., Assistant Professor of Anatomy, Western Reserve University, Medical Department, *1353 East 9th Street, Cleveland, Ohio.*

Blair, Vilray Papin, A.M., M.D., Clinical Professor of Surgery, Medical Department, Washington University, *400 Metropolitan Building, St. Louis, Mo.*

Blaisdell, Frank Ellsworth, Sr., M.D., Assistant Professor of Surgery, Medical Department of Stanford University, *1520 Lake Street, San Francisco, Calif.*

Blake, Joseph Augustus, A.B., M.D., *40 Ave. Henri Martin, Paris, France.*

Bonney, Charles W., A.B., M.D., Demonstrator in Anatomy, *Jefferson Medical College, Philadelphia, Pa.*

Boyden, Edward Allen, A.M., Ph.D., Instructor of Comparative Anatomy, *Harvard Medical School, Boston, Mass.*

Bremer, John Lewis, M.D. (Ex. Com. '15-), Associate Professor of Histology, *Harvard Medical School, Boston, Mass.*

Broadnax, John W., Ph.G., M.D., Associate Professor of Anatomy, *Medical College of Virginia, Richmond, Va.*

Brookover, Charles, Ph.D., Professor of Anatomy, *University of Arkansas, Little Rock, Arkansas.*

Brooks, William Allen, A.M., M.D., *167 Beacon Street, Boston, Mass.*

Brown, A. J., A.B., M.D., Instructor in Anatomy, Columbia University, *156 East 64th Street, New York, N. Y.*

Browning, William, Ph.D., M.D., Professor of Nervous and Mental Diseases, Long Island College Hospital, *54 Lefferts Place, Brooklyn, N. Y.*

Bryce, Thomas H., M.A., M.D., Regius Professor of Anatomy, University of Glasgow, *No. 2, The University, Glasgow, Scotland.*

Bullard, H. Hays, A.M., Ph.D., M.D., Assistant in Pathology, *Johns Hopkins Medical School, Baltimore, Md.*

Bunting, Charles Henry, B.S., M.D., Professor of Pathology, *University of Wisconsin, 2020 Chadbourne Avenue, Madison, Wis.*

Burr, Harold Saxton, Ph.B., Ph.D., Instructor in Anatomy, School of Medicine, *Yale University, New Haven, Conn.*

Burrows, Montrose T., A.B., M.D., Acting Resident Pathologist, *Johns Hopkins Hospital, Baltimore, Md.*

Byrnes, Charles M., B.S., M.D., Instructor in Neurology, Johns Hopkins Medical School, *207 E. Preston St., Baltimore, Md.*

Campbell, William Francis, A.B., M.D., Professor of Anatomy and Histology, Long Island College Hospital, *394 Clinton Avenue, Brooklyn, N. Y.*

Carey, Eben J., Instructor in Anatomy, *Creighton University Medical Department, Omaha, Neb.*

Carpenter, Frederick Walton, Ph.D., Professor of Biology, *Trinity College, Hartford, Conn.*

Carver, Gail L., A.B., A.M., Professor of Biology, *Mercer University, Macon, Ga.*

Casamajor, Louis, B.A., M.D., Assistant Professor of Neurology, Columbia University, *437 West 59th Street, New York City.*

Chambers, Robert, Jr., A.M., Ph.D., Instructor in Anatomy, *Cornell University Medical College, New York City.*

Cheever, David, A.B., M.D., Assistant Professor of Surgical Anatomy, Harvard Medical School, *20 Hereford Street, Boston, Mass.*

CHIDESTER, FLOYD E., A.M., Ph.D., Associate Professor of Zoölogy, *Rutgers College, New Brunswick, N. J.*

CHILD, CHARLES MANNING, Ph.D., Associate Professor of Zoölogy, *University of Chicago, Chicago, Ill.*

CHILLINGWORTH, FELIX P., M.D., Assistant Professor of Physiology and Pharmacology, *Tulane University, New Orleans, La.*

CLAPP, CORNELIA MARIA, Ph.D., Professor of Zoölogy, *Mount Holyoke College, South Hadley, Mass.*

CLARK, ELBERT, B.S., M.D., Assistant Professor of Anatomy, *University of Chicago, Chicago, Ill.*

CLARK, ELEANOR LINTON, A.M., Research Worker, Department of Anatomy, *413 S. 6th Street, University of Missouri, Columbia, Mo.*

CLARK, ELIOT R., A.B., M.D. (Ex. Com. '16–), Professor of Anatomy, *University of Missouri, 413 S. 6th Street, Columbia, Mo.*

COE, WESLEY R., Ph.D., Professor of Biology, *Sheffield Scientific School, Yale University, New Haven, Conn.*

COGHILL, GEORGE E., Ph.D., Associate Professor of Anatomy, University of Kansas Medical School, *338 Illinois Street, Lawrence, Kans.*

COHN, ALFRED E., M.D., Associate Member, Rockefeller Institute for Medical Research, *315 Central Park West, New York, N. Y.*

COHOE, BENSON A., A.B., M.B., Associate Professor of Therapeutics, University of Pittsburgh, *705 North Highland Avenue, Pittsburgh, Pa.*

CONANT, WILLIAM MERRITT, M.D., Professor of Clinical Surgery, Tufts Medical School, *486 Commonwealth Avenue, Boston, Mass.*

CONGDON, EDGAR DAVIDSON, Ph.D., Assistant Professor of Anatomy, Leland Stanford University, School of Medicine, *330 Coleridge Avenue, Palo Alto, Calif.*

CONKLIN, EDWIN GRANT, A.M., Ph.D., Sc.D., Professor of Biology, Princeton University, *139 Broadmead Avenue, Princeton, N. J.*

CORNER, GEORGE W., A.B., M.D., Assistant Professor of Anatomy, *Anatomical Laboratory, University of California, Berkeley, Calif.*

CORNING, H. K., M.D., Professor of Anatomy, *Bündesstr. 17, Basel, Switzerland.*

COWDRY, EDMUND V., Ph.D., Associate in Anatomy, *Anatomical Laboratory, Johns Hopkins Medical School, Baltimore, Md.*

CRAIG, JOSEPH DAVID, A.M., M.D., *12 Ten Broeck Street, Albany, N. Y.*

CRILE, GEORGE W., A.M., M.D., F.A.C.S., Professor of Surgery, Western Reserve University, *1021 Prospect Avenue, Cleveland, O.*

CULLEN, THOMAS S., M.D., *20 E. Eager Street, Baltimore, Md.*

CUMMINS, HAROLD, A.B., Instructor in Histology and Embryology, *Vanderbilt University Medical School, Nashville, Tenn.*

CUNNINGHAM, ROBERT S., B.S., A.M., M.D., Assistant in Anatomy, Johns Hopkins Medical School, *2021 E. 31st Street, Baltimore, Md.*

CURTIS, GEORGE M., A.M., Ph.D., Professor of Anatomy, Medical Department of the Vanderbilt University, *Vanderbilt West Campus, Nashville, Tenn.*

DAHLGREN, ULRIC, A.B., M.S., Professor of Biology, Princeton University, *204 Guyot Hall, Princeton, N. J.*

DANCHAKOFF, VERA, M.D., Instructor in Anatomy, Columbia University, *437 W. 59th Street, New York City.*

DANFORTH, CHARLES HASKELL, A.M., Ph.D., Associate Professor of Anatomy, *Washington University Medical School, St. Louis, Mo.*

DARRACH, WILLIAM, A.M., M.D., Assistant Attending Surgeon, Presbyterian Hospital, Instructor in Clinical Surgery, Columbia University, *47 West 50th Street, New York, N. Y.*

DAVIS, DAVID M., B.S., M.D., Instructor in Urology and Pathologist, Brady Urological Institute, *Johns Hopkins Hospital, 709 St. Paul Street, Baltimore Md.*

DAVIS, HENRY K., A.B., A.M., Instructor in Anatomy, *Cornell University Medical College, Ithaca, N. Y.*

DEAN, BASHFORD, Ph.D., Professor of Vertebrate Zoölogy, Columbia University, Curator of Fishes and Reptiles, American Museum Natural History, *Riverdale-on-Hudson, New York City.*

DETWILER, SAMUEL RANDALL, Ph.D., Assistant in Biology, *Yale University, New Haven, Conn.*

DEXTER, FRANKLIN, M.D., *247 Marlborough Street, Boston, Mass.*

DIXON, A. FRANCIS, M.B., Sc.D., University Professor of Anatomy, Trinity College, *73 Grosvenor Road, Dublin, Ireland.*

DODSON, JOHN MILTON, A.M., M.D., Dean and Professor of Medicine, Rush Medical College, University of Chicago, *5806 Blackston Avenue, Chicago, Ill.*

DOLLEY, D. H., M.D., Professor of Pathology, *University of Missouri, Columbia, Mo.*

DONALDSON, HENRY HERBERT, Ph.D., D.Sc. (Ex. Com. '09–'13, Pres. '16–), Professor of Neurology, *The Wistar Institute of Anatomy and Biology, Woodland Avenue and 36th Street, Philadelphia, Pa.*

DOWNEY, HAL, M.A., Ph.D., Associate Professor of Histology, *Department of Animal Biology, University of Minnesota, Minneapolis, Minn.*

DUBREUIL, G., M.D., Professor of Anatomy, *Institut d'Anatomie, Universite de Bordeaux, Bordeaux, France.*

DUESBERG, JULES, M.D., Research Associate, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*

DUNN, ELIZABETH HOPKINS, A.M., M.D., *Marine Biological Laboratory, Woods Hole, Mass.*

EATON, PAUL BARNES, A.B., M.D., *1306 W. Lexington St., Baltimore, Md.*

ECCLES, ROBERT G., M.D., Phar.D., *681 Tenth Street, Brooklyn, N. Y.*

EDWARDS, CHARLES LINCOLN, Ph.D., Director of Nature Study, Los Angeles City Schools, *1032 West 39th Place, Los Angeles, Calif.*

EGGERTH, ARNOLD HENRY, Assistant in Anatomy, *University of Michigan, 516 Walnut Street, Ann Arbor, Michigan.*

EMMEL, VICTOR E., M.S., Ph.D., Assistant Professor of Anatomy, University of Illinois College of Medicine, *Congress and Honore Streets, Chicago, Ill.*

ESSICK, CHARLES RHEIN, B.A., M.D., *520 Franklin Street, Reading, Pa.*

EVANS, HERBERT MCLEAN, B.S., M.D., Professor of Anatomy, *University of California, Berkeley, Calif.*

EVATT, EVELYN JOHN, B.S., M.B., Professor of Anatomy, *Royal College of Surgeons, Dublin, Ireland.*

EYCLESHYMER, ALBERT CHAUNCEY, Ph.D., M.D., Professor of Anatomy, *Medical Department, University of Illinois, Honore and Congress Streets, Chicago, Ill.*

Ferris, Harry Burr, A.B., M.D., Hunt Professor of Anatomy and Head of the Department of Anatomy, Medical Department, Yale University, *395 St. Ronan Street, New Haven, Conn.*

Fetterolf, George, A.B., M.D., Sc.D., Assistant Professor of Anatomy, University of Pennsylvania, *134 South 20th Street, Philadelphia, Pa.*

Fischelis, Philip, M.D., Associate Professor of Histology and Embryology, Medico-Chirurgical College, *828 North 5th Street, Philadelphia, Pa.*

Fisher, Homer G., A.M., Student, *Johns Hopkins Medical School, Baltimore, Md.*

Flint, Joseph Marshall, B.S., A.M., M.D. (Second Vice-Pres. '00–'04), Professor of Surgery, Yale University, *320 Temple Street, New Haven, Conn.*

Gage, Simon Henry, B.S. (Ex. Com. '06–'11), Emeritus Professor of Histology, *Cornell University, 4 South Avenue, Ithaca, N. Y.*

Gallaudet, Bern Budd, A.M., M.D., Assistant Professor of Anatomy, Columbia University, Consulting Surgeon Bellevue Hospital, *110 East 16th Street, New York, N. Y.*

Geddes, A. Campbell, M.B., M.D., Ch.B., F.R.S.E., Professor of Anatomy, *McGill University, Montreal, Canada.*

Gee, Wilson, M.A., Ph.D., Professor of Biology, *Emory University, Oxford, Ga.*

Gibson, G. H., M.D., *Waitangi, Chatham Islands, Wellington, New Zealand.*

Gibson, James A., M.D., Professor of Anatomy, Medical Department, University of Buffalo, *24 High Street, Buffalo, N. Y.*

Gilman, Philip Kingsworth, B.A., M.D., F.A.C.S., Professor of Surgery, University of Philippines, *Care of C. E. Gilman, Syndicate Building, Oakland, Calif.*

Globus, J. H., B.A., Assistant in Anatomy, *Cornell University Medical College, New York City.*

Goetsch, Emil, Ph.D., M.D., Associate Surgeon, *Johns Hopkins Hospital, Baltimore, Md.*

Greene, Charles W., A.M., Ph.D., Professor of Physiology and Pharmacology, *University of Missouri, 814 Virginia Avenue, Columbia, Mo.*

Greenman, Milton J., Ph.B., M.D., Sc.D., Director of *The Wistar Institute of Anatomy and Biology, 36th Street and Woodland Avenue, Philadelphia, Pa.*

Gudernatsch, J. F., Ph.D., Assistant Professor of Anatomy, *Cornell University Medical College, New York City.*

Guild, Stacy R., A.M., Instructor in Anatomy, University of Michigan, *1115 Lincoln Avenue, Ann Arbor, Mich.*

Guyer, Michael F., Ph.D., Professor of Zoölogy, *University of Wisconsin, Madison, Wis.*

Halsted, William Stewart, M.D., Professor of Surgery, Johns Hopkins University, *1201 Eutaw Place, Baltimore, Md.*

Hamann, Carl A., M.D. (Ex. Com. '02–'04), Professor of Applied Anatomy and Clinical Surgery, Western Reserve University, *416 Osborn Building, Cleveland, Ohio.*

Hardesty, Irving, A.B., Ph.D. (Ex. Com. '10 and '12–'15), Professor of Anatomy and head of Department of Anatomy, *Tulane University of Louisiana, Station 20, New Orleans, La.*

HARE, EARL R., A.B., M.D., F.A.C.S., Instructor in Surgery, University of Minnesota, *623 Syndicate Building, Minneapolis, Minn.*

HARRISON, ROSS GRANVILLE, Ph.D., M.D. (Pres. '12–'13), Bronson Professor of Comparative Anatomy, *Osborn Zoölogical Laboratory, Yale University, New Haven, Conn.*

HARVEY, BASIL COLEMAN HYATT, A.B., M.B., Associate Professor of Anatomy, University of Chicago, *Department of Anatomy, University of Chicago, Chicago, Ill.*

HATAI, SHINKISHI, Ph.D., Associate in Neurology, *Wistar Institute of Anatomy and Biology, 36th Street and Woodland Avenue, Philadelphia, Pa.*

HATHAWAY, JOSEPH H., A.M., M.D., Professor of Anatomy, Anatomical Department, *Detroit Medical College, Detroit, Mich.*

HAZEN, CHARLES MORSE, A.M., M.D., Professor of Physiology, *Medical College of Virginia, Richmond, Bon Air, Va.*

HEAGEY, FRANCIS WENGER, A.B., M.D., Assistant Professor of Anatomy, *Creighton Medical College, Omaha, Neb.*

HEISLER, JOHN C., M.D., Professor of Anatomy, Medico-Chirurgical College, *3829 Walnut Street, Philadelphia, Pa.*

HELDT, THOMAS JOHANES, A.B., A.M., *200 East Lanvale Street, Baltimore, Md.*

HERRICK, CHARLES JUDSON, Ph.D. (Ex. Com. '13–) Professor of Neurology, University of Chicago, *Laboratory of Anatomy, University of Chicago, Chicago, Ill.*

HERTZLER, ARTHUR E., M.D., F.A.C.S., Associate in Surgery, University of Kansas, *1816 Rialto Building, Kansas City, Mo.*

HERZOG, MAXIMILIAN, M.D., LL.D., Professor of Pathology and Dean Medical Department, Lagola University, *1358 Fulton Street, Chicago, Ill.*

HEUSER, CHESTER H., A.M., Ph.D., Fellow in Anatomy, *Wistar Institute of Anatomy, 36th Street and Woodland Avenue, Philadelphia, Pa.*

HEWSON, ADDINELL, A.M., M.D., Professor of Anatomy, Philadelphia Polyclinic for Graduates in Medicine, *2120 Spruce Street, Philadelphia, Pa.*

HILL, HOWARD, M.D., *1010 Rialto Building, Kansas City, Mo.*

HILL, JAMES PETER, D.Sc., F.R.S., Todrell Professor of Zoölogy and Comparative Anatomy, University of London, *University College, Gower Street, London, W.C., England.*

HILTON, WILLIAM A., Ph.D., Professor of Zoölogy, *Pomona College, Claremont, Calif.*

HOEVE, HUBERTUS H. J., M.D., *Hoeve Hospital, Meherrin, Virginia.*

HOLT, CAROLINE M., A.B., Ph.D., Assistant Professor of Biology, *Simmons College, Boston, Mass.*

HOOKER, DAVENPORT, M.A., Ph.D., Assistant Professor of Anatomy, *Anatomical Laboratory, Yale University School of Medicine, New Haven, Conn.*

HOPEWELL-SMITH, ARTHUR, L.R.C.P., M.R.C.S., L.D.S., Professor of Dental Histology, Histo-Pathology, Comparative Odontology, *University of Pennsylvania Dental College, Philadelphia, Pa.*

HOPKINS, GRANT SHERMAN, Sc.D., D.V.M., Professor Comparative Veterinary Anatomy, *Cornell University, Ithaca, N. Y.*

HOSKINS, ELMER R., A.B., A.M., Ph.D., Instructor in Anatomy, New York University and Bellevue Medical College, *338 East 26th Street, New York City.*

HRDLIČKA, ALES, M.D., Curator of the Division of Physical Anthropology, *United States National Museum, Washington, D. C.*

HUBER, G. CARL, M.D. (Second Vice-Pres. '00–'01, Secretary-Treasurer '02–'13, Pres. '14–'15) Professor of Anatomy and Director of the Anatomical Laboratories, University of Michigan, *1330 Hill Street, Ann Arbor, Mich.*

HUNTINGTON, GEORGE S., A.M., M.D., D.Sc., LL.D. (Ex. Com. '95–'97, '04–'07, Pres. '99–'03), Professor of Anatomy, Columbia University, *437 West 59th Street, New York, N. Y.*

INGALLS, N. WILLIAM, M.D., Associate Professor of Anatomy, *Western Reserve University, St. Clair and East 9th Streets, Cleveland, Ohio.*

JACKSON, CLARENCE M., M.S., M.D. (Ex. Com. '10–'14, Vice-Pres. '16), Professor and Head of the Department of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

JENKINS, GEORGE B., M.D., Professor of Anatomy, *State University of Iowa, Iowa City, Iowa.*

JOHNSON, CHARLES EUGENE, A.M., Ph.D., Instructor in Comparative Anatomy of Vertebrates, *Department of Animal Biology, University of Minnesota, Minneapolis, Minn.*

JOHNSON, FRANKLIN P., A.M., Ph.D., Associate Professor of Anatomy, *University of Missouri, 412 Stewart Road, Columbia, Mo.*

JOHNSON, SYDNEY E., Ph.D., Instructor in Anatomy, *Northwestern University Medical School, Chicago, Ill.*

JOHNSTON, JOHN B., Ph.D., Professor of Neurology, *University of Minnesota, Minneapolis, Minn.*

JORDAN, HARVEY ERNEST, Ph.D., Professor of Histology and Embryology, University of Virginia, *34 University Place, University, Va.*

KAMPMEIER, OTTO FREDERICK, A.B., Ph.D., Assistant Professor of Comparative Anatomy and Embryology, *University of Pittsburgh, School of Medicine, Pittsburgh, Pa.*

KAPPERS, CORNELIUS UBBO ARIËNS, M.D., Director of the *Central Institute for Brain Research of Holland, Mauritskade 61, Amsterdam, Holland.*

KEEGAN, JOHN J., A.M., M.D., Instructor in Anatomy, *University of Nebraska Medical College, Omaha, Neb.*

KEILLER, WILLIAM, L.R.C.P. and F.R.C.S.Ed. (Second Vice-Pres. '98–'99), Professor of Anatomy, Medical Department University of Texas, *State Medical College, Galveston, Texas.*

KEITH, ARTHUR, M.D., LL.D., F.R.C.S., F.R.S., Hunterian Professor of Anatomy, *College of Surgeons, London, England.*

KERNAN, JOHN D., JR., A.B., M.D., Assistant in Anatomy, Columbia University, *437 West 59th Street, New York City.*

KERR, ABRAM T., B.S., M.D. (Ex. Com. '10–'14), Professor of Anatomy, *Cornell University Medical College, Ithaca, N. Y.*

KEY, J. A., B.S., Instructor in Anatomy, *Creighton Medical College, Omaha, Neb.*

KINGERY, HUGH MCMILLAN, A.M., Instructor in Histology and Embryology, *Cornell University, Ithaca, N. Y.*

KINGSBURY BENJAMIN F., Ph.D., M.D., Professor of Histology and Embryology, Cornell University, *802 University Avenue, Ithaca, N. Y.*

KINGSLEY, JOHN STERLING, Sc.D., Professor of Zoölogy, *University of Illinois, Urbana, Ill.*

King, Helen Dean, A.B., A.M., Ph.D., Assistant Professor of Embryology, *Wistar Institute of Anatomy, 36th Street and Woodland Avenue, Philadelphia, Pa.*

Kirkham, William Barri, Ph.D., Instructor in Biology, *Sheffield Scientific School, Yale University, New Haven, Conn.*

Knower, Henry McE., A.B., Ph.D. (Ex. Com. '11–'15), Professor of Anatomy, *Medical Department, University of Cincinnati, Station V, Cincinnati, Ohio.*

Koch, John C., B.A., Student of Medicine, *Johns Hopkins Medical School, Baltimore, Md.*

Kofoid, Charles Atwood, Ph.D., Professor of Zoölogy, University of California, Assistant Director San Diego Marine Biological Station, *2616 Etna Street, Berkeley, Calif.*

Kunitomo, Kanae, M.D., Professor of Anatomy, *Nagasaki Medical School, Nagasaki, Japan.*

Kunkel, Beverly Waugh, Ph.B., Ph.D., Professor of Zoölogy, *Lafayette College, Easton, Pa.*

Kuntz, Albert, Ph.D., Associate Professor of Histology and Biology, Department of Anatomy, *St. Louis University School of Medicine, St. Louis, Mo.*

Kutchin, Mrs. Harriet Lehmann, A.M., *"The Maplewood," Green Lake, Wisconsin.*

Kyes, Preston, A.M., M.D., Assistant Professor of Experimental Pathology, *Department of Pathology, University of Chicago, Chicago, Ill.*

Lambert, Adrian V. S., A.B., M.D., Associate Professor of Surgery, Columbia University, *168 East 71st Street, New York, N. Y.*

Landacre, Francis Leroy, A.B., Ph.D., Professor of Anatomy, Ohio State University, *2026 Inka Avenue, Columbus, Ohio.*

Lane, Michael Andrew, B.S., *122 S. California Avenue, Chicago, Ill.*

Latimer, Homer B., A.M., Associate Professor of Zoölogy, University of Nebraska, *1909 South 27th Street, Lincoln, Neb.*

Laurens, Henry, Ph.D., Instructor in Biology, *Yale University, New Haven, Conn.*

Lee, Thomas G., B.S., M.D. (Ex. Com. '08–'10, Vice Pres. '12–'13), Professor of Comparative Anatomy, University of Minnesota, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

Leidy, Joseph, Jr., A.M., M.D., *1319 Locust Street, Philadelphia, Pa.*

Lewis, Dean D., M.D., Assistant Professor of Surgery, Rush Medical College, *People's Gas Building, Chicago, Ill.*

Lewis, Frederic T., A.M., M.D. (Ex. Com. '09–'13, Vice-Pres. '14–'15), Associate Professor of Embryology, *Harvard Medical School, Boston, Mass.*

Lewis, Margaret Reed, M.A., Collaborator, Department of Embryology, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*

Lewis, Warren Harmon, B.S., M.D. (Ex. Com. '09–'11, '14–), Professor of Physiological Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

Lillie, Frank Rathay, Ph.D., Professor of Embryology, Chairman of Department of Zoölogy, University of Chicago; Director Marine Biological Laboratory, Woods Hole, Mass., *University of Chicago, Chicago, Ill.*

Lineback, Paul Eugene, A.B., M.D., Associate Professor of Anatomy, *Atlanta Medical College, Emory University, Atlanta, Ga.*

Locy, William A., Ph.D., Sc.D., Professor of Zoölogy and Director of the Zoölogical Laboratory, Northwestern University, *1745 Orrington Avenue, Evanston, Ill.*

Loeb, Hanau Wolf, A.M., M.D., Professor and Director of the Department of the Diseases of the Ear, Nose and Throat, St. Louis University, *537 North Grand Avenue, St. Louis, Mo.*

Lord, Frederic P., A.B., M.D., Professor of Anatomy and Histology, *Dartmouth Medical School, Hanover, N. H.*

Lowrey, Lawson Gentry, A.M., Fellow in Neuropathology, Harvard Medical School; Pathologist, *Danvers State Hospital, Hawthorne, Mass.*

Macklin, C. C., M.B., Instructor in Anatomy, Department of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

McClung, Clarence E., A.M., Ph.D., Professor of Zoölogy, *University of Pennsylvania, Philadelphia, Pa.*

McClure, Charles Freeman Williams, A.M., Sc.D. (Vice-Pres. '10–'11. Ex. Com. '12–'16), Professor of Comparative Anatomy, *Princeton University, Princeton, N. J.*

McCormack, William Eli, M.D., Adjunct Professor of Anatomy, University of Louisville, Medical Department, *101 W. Chestnut Street, Louisville, Ky.*

McCotter, Rollo E., M.D., Professor of Anatomy, Medical Department, University of Michigan, *809 E. University Avenue, Ann Arbor, Mich.*

McFarland, Frank Mace, A.M., Ph.D., Professor of Histology, *Leland Stanford Junior University, 2 Cabrillo Avenue, Stanford University, Calif.*

McGill, Caroline, A.M., Ph.D., M.D., Pathologist, *Murray Hospital, Butte, Mont.*

McKibben, Paul S., Ph.D., Professor of Anatomy, *Faculty of Medicine, Western University, London, Ontario, Canada.*

McMurrich, James Playfair, A.M., Ph.D., LL.D. (Ex. Com. '06–'07, Pres. '08–'09), Professor of Anatomy, University of Toronto, *Toronto, Canada.*

McWhorter, John E., M.D., Worker under George Crocker Research Fund, College of Physicians and Surgeons, Columbia University, *205 West 107th Street, New York, N. Y.*

Mall, Franklin P., A.M., M.D., LL.D., D.Sc. (Ex. Com. '00–'05, Pres. '06–'07), Professor of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

Mangum, Charles S., A.B., M.D., Professor of Anatomy, *University of North Carolina, Chapel Hill, N. C.*

Malone, Edward Fall, A.B., M.D., Associate Professor of Anatomy, *University of Cincinnati, College of Medicine, Station V, Cincinnati, Ohio.*

Mark, Edward Laurens, Ph.D., LL.D., Hersey Professor of Anatomy and Director of the Zoölogical Laboratory, Harvard University, *109 Irving Street, Cambridge, Mass.*

Matas, Rudolph, M.D., LL.D., Professor of Surgery, Tulane University of Louisiana, *2255 St. Charles Avenue, New Orleans, La.*

Maximow, Alexander, M.D., Professor of Histology and Embryology at the Imperial Military Academy of Medicine, Petrograd, Russia, *Botkinskaja 2, Petrograd, Russia.*

Mellus, Edward Lindon, M.D., *12 Fuller Street, Brookline, Mass.*

Mercer, William F., Ph.M., Ph.D., Professor of Biology, Ohio University, *Box 384, Athens, Ohio.*

METHENY, D. GREGG, M.D., L R.C.P., L.R.C.S., Edin.—L.F.P.S., Glasg., Associate in Anatomy, *Jefferson Medical College, 11th and Clinton Streets, Philadelphia, Pa.*

MEYER, ADOLF, M.D., LL.D., Professor of Psychiatry and Director of the Henry Phipps Psychiatric Clinic, *Johns Hopkins Hospital, Baltimore, Md.*

MEYER, ARTHUR W., S.B., M.D. (Ex. Com. '12–'16), Professor of Anatomy, Leland Stanford Junior University, *Stanford University, Calif.*

MILLER, ADAM M., *A.M.*, Professor of Anatomy, Long Island College Hospital, *335 Henry Street, Brooklyn, N. Y.*

MILLER, M. M., Ph.D., Instructor in Anatomy, *North Western University Medical School, Chicago, Ill.*

MILLER, WILLIAM SNOW, M.D. (Vice-Pres. '08–'09), Associate Professor of Anatomy, University of Wisconsin, *2001 Jefferson Street, Madison, Wis.*

MIXTER, SAMUEL JASON, B.S., M.D., Visiting Surgeon Massachusetts General Hospital, *180 Marlboro Street, Boston, Mass.*

MOODIE, ROY L., A.B., Ph.D., Instructor in Anatomy, *University of Illinois Medical College, Congress and Honore Streets, Chicago, Ill.*

MOODY, ROBERT ORTON, B.S., M.D., Associate Professor of Anatomy, University of California, *2826 Garber Street, Berkeley, Calif.*

MORRILL, CHARLES V., A.M., Ph.D., Instructor in Anatomy, *Cornell University Medical School, 1st Avenue and 28th Street, New York, N. Y.*

MORRIS, MARGARET, B.A., Ph.D., *Osborn Zoölogical Laboratory, Yale University, New Haven, Conn.*

MULLER, HENRY R., A.B., M.D., Assistant in Pathology, *Cornell University Medical College, 1st Avenue and 28th Street, New York, N. Y.*

MUNSON, JOHN P., M.S., Ph.D., Head of the Department of Biology, Washington State Normal School, *706 North Anderson Street, Ellensburg, Washington.*

MURPHEY, HOWARD S., D.V.M., Professor of Anatomy and Histology, *519 Welch Avenue, Station A, Ames, Ia.*

MURRAY, H. A., JR., A.B., Student, Columbia University, College of Physicians and Surgeons, *437 West 59th Street, New York City.*

MYERS, BURTON D., A.M., M.D., Professor of Anatomy and Secretary of the Indiana University School of Medicine, *Indiana University, Bloomington, Ind.*

MYERS, JAY A., M.S., Ph.D., Instructor in Anatomy, *University of Minnesota, 624 University Avenue, S. E., Minneapolis, Minn.*

MYERS, MAE LICHTENWALNER, M.D., Associate Professor of Anatomy and Director of the Laboratories of Histology and Embryology, *Women's Medical College of Pennsylvania, North College Avenue and 21st Street, Philadelphia, Pa.*

NACHTRIEB, HENRY FRANCIS, B.S., Professor of Animal Biology and Head of the Department, University of Minnesota, *905 6th Street, S.E., Minneapolis, Minn.*

NEAL, HERBERT VINCENT, Ph.D., Professor of Zoölogy, Tufts College, *Tufts College, Mass.*

NOBLE, HARRIET ISABEL, *262 Putnam Avenue, Brooklyn, N. Y.*

NORRIS, EDGAR H., B.S., A.M., Assistant in Anatomy, *University of Minnesota, Minneapolis, Minn.*

Norris, H. W., A.B., Professor of Zoölogy, *Grinnell College, Grinnell, Iowa.*

Painter, Theophilus S., Ph.D., Instructor in Biology, *Sheffield Scientific School, Yale University, New Haven, Conn.*

Papanicolaou, George, Ph.D., M.D., Instructor in Anatomy, *Cornell University Medical College, New York City.*

Papez, James Wenceslas, B.A., M.D., Professor of Anatomy, Histology and Embryology, *Atlanta Medical College, 94 Butler Street, Atlanta, Ga.*

Parker, George Howard, D.Sc., Professor of Zoölogy, Harvard University, *16 Berkeley Street, Cambridge, Mass.*

Paton, Stewart, A.B., M.D., Lecturer in Biology, *Princeton University, Princeton, N. J.*

Patten, William, Ph.D., Professor of Zoölogy, *Dartmouth College, Hanover, N. H.*

Paterson, A. Melville, M.D., F.R.C.S., Professor of Anatomy, *University of Liverpool, Liverpool, England.*

Patterson, John Thomas, Ph.D., Professor and Chairman of the School of Zoölogy, University of Texas, *University Station, Austin, Texas.*

Pfeiffer, John A. F., M.A., M.D., Senior Asst. Physician and Pathologist, *Government Hospital for the Insane, Washington, D. C.*

Piersol, George A., M.D., Sc.D. (Vice-Pres. '93–'94, '98–'99, '06–'07, Pres. '10–'11), Professor of Anatomy, University of Pennsylvania, *4724 Chester Avenue, Philadelphia, Pa.*

Piersol, William Hunter, A.B., M.B., Associate Professor of Histology and Embryology, University of Toronto, *26 Albany Avenue, Toronto, Canada.*

Pohlman, Augustus G., M.D., Professor of Anatomy, Medical Department, St. Louis University, *1402 South Grand Avenue, St. Louis, Mo.*

Potter, Peter, M.S., M.D., Oculist and Aurist, Murray Hospital, Butte, Montana, *411–413 Hennessy Building, Butte, Montana.*

Poynter, Charles W. M., B.S., M.D., Professor of Anatomy, *College of Medicine, University of Nebraska, Omaha, Neb.*

Prentiss, H. J., M.D., M.E., *Iowa City, Iowa.*

Pryor, Joseph William, M.D., Professor of Anatomy and Physiology, State College of Kentucky, *261 North Broadway, Lexington, Ky.*

Radasch, Henry E., M.S., M.D., Assistant Professor of Histology and Embryology, Jefferson Medical College, *Daniel Baugh Institute of Anatomy, 11th and Clinton Streets, Philadelphia, Pa.*

Ranson, Stephen W., M.D., Ph.D., Professor of Anatomy, Northwestern University Medical School, *2431 Dearborn Street, Chicago, Ill.*

Rasmussen, Andrew T., A.B., Ph.D., Instructor in Neurology, *University of Minnesota, Minneapolis, Minn.*

Reagan, Franklin P., Ph.D., Fellow in Biology, *Princeton University, Princeton, N. J.*

Reed, Hugh Daniel, Ph.D., Assistant Professor of Zoölogy, Cornell University, McGraw Hall, *Ithaca, N. Y.*

Reese, Albert Moore, A.B., Ph.D., Professor of Zoölogy, *West Virginia University, Morgantown, W. Va.*

Retzer, Robert, M.D., Associate Professor of Anatomy, University of Pittsburgh, *Anatomical Laboratories, University of Pittsburgh, Pittsburgh, Pa.*

Revell, Daniel Graisberry, A.B., M.B., Professor of Anatomy, University of Alberta, *Edmonton, Alberta, Canada.*

RHINEHART, D. A., M.D., Professor of Anatomy, University of Arkansas, *Old State House, Little Rock. Ark.*

RICE, EDWARD LORANUS, Ph.D., Professor of Zoölogy, *Ohio Wesleyan University, Delaware, Ohio.*

RINGOEN, ADOLPH R., Assistant in the Department of Animal Biology, *University of Minnesota, Minneapolis, Minn.*

ROBERTSON, ALBERT DUNCAN, B.A., Professor of Biology, *Western University, London, Ontario, Canada.*

ROBINSON, ARTHUR, M.D., F.R.C.S. (Edinburgh), Professor of Anatomy, University of Edinburgh, *The University, Anatomy Department, Edinburgh, Scotland.*

ROSE, FRANK H., A.B., Austin Teaching Fellow, *Harvard Medical School, Boston, Mass.*

RUTH, EDWARD S., M.D., Professor of Anatomy, *University of the Philippines, College of Medicine and Surgery, Manila, P. I.*

SABIN, FLORENCE R., B.S., M.D. (Second Vice-Pres. '08–'09), Associate Professor of Anatomy, *Johns Hopkins University, Medical Department, Baltimore, Md.*

SANTEE, HARRIS E., A.M., Ph.D., M.D., Professor of Anatomy, Jenner Medical College, and Professor of Neural Anatomy, Chicago College of Medicine and Surgery, *2806 Warren Avenue, Chicago, Ill.*

SCAMMON, RICHARD E., Ph.D., Professor of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

SCHAEFER, MARIE CHARLOTTE, M.D., Associate Professor of Biology, Histology and Embryology, *Medical Department, University of Texas, 701 North Pine Street, San Antonio, Texas.*

SCHAEFFER, JACOB PARSONS, A.M., M.D., Ph.D., Professor of Anatomy and Director of the Daniel Baugh Institute of Anatomy, *Jefferson Medical College, 11th and Clinton Streets, Philadelphia, Pa.*

SCHOCHET, SIDNEY SIGSFRIED, M.D., Instructor in Gynaecology, Northwestern University, *Marshall Field, Annex Building, Chicago, Ill.*

SCHOEMAKER, DANIEL M., B.S., M.D., Professor of Anatomy, Medical Department, St. Louis University, *1402 South Grand Avenue, St. Louis, Mo.*

SCHULTE, HERMANN VON W., A.B., M.D. (Ex. Com. '15-) Associate Professor of Anatomy, Columbia University, *437 West 59th Street, New York, N. Y.*

SCHULTZ, ADOLPH H., Ph.D., Collaborator in Embryology, Carnegie Institution, *Johns Hopkins Medical School, Baltimore, Md.*

SCHMITTER, FERDINAND, A.B., M.D., *Captain Medical Corps, U. S. Army, Columbus Barracks, Columbus, Ohio.*

SCOTT, JOHN W., A.M., Ph.D., Professor of Zoölogy, *University of Wyoming, Laramie, Wyo.*

SCOTT, KATHERINE JULIA, A.B., M.D., Assistant in Anatomy, *University of California, Berkeley, Calif.*

SELLING, LAWRENCE, A.B., M.D., *Selling Building, Portland, Ore.*

SENIOR, H. D., M.B., D.Sc., F.R.C.S., Professor of Anatomy, New York University, and Bellevue Hospital Medical College, *338 East 26th Street, New York, N. Y.*

SHARP, CLAYTON, A.B., M.D., Instructor in Anatomy, Columbia University, *College of Physicians and Surgeons, New York City.*

Sheldon, Ralph Edward, A.M., M.S., Ph.D., Professor of Anatomy, *University of Pittsburgh Medical School, Grant Boulevard, Pittsburgh, Pa.*

Shields, Randolph Tucker, A.B., M.D., Dean, *University of Nanking Medical School, Nanking, China.*

Shufeldt, R. W., M.D., Major Medical Corps, U. S. A. (Retired), *3356 Eighteenth Street, N. W., Washington, D. C.*

Silvester, Charles Frederick, Curator of the Zoölogical Museum and Assistant in Anatomy, Princeton University, *10 Nassau Hall, Princeton, N. J.*

Simpson, Sutherland, M.D., D.Sc., F.R.S.E. (Edin.), Professor of Physiology, *Cornell University Medical College, Ithaca, N. Y.*

Sisson, Septimus, B.S., V.S., Professor of Comparative Anatomy, Ohio State University, *274 14th Avenue, Columbus, Ohio.*

Sluder, Greenfield, M.D., Clinical Professor of Laryngology, Washington University Medical School, *3542 Washington Avenue, St. Louis, Mo.*

Smith, Charles Dennison, A.M., M.D., Superintendent Maine General Hospital Professor of Physiology, Medical School of Maine, *Maine General Hospital, Portland, Me.*

Smith, George Milton, A.M., M.D., Director Barnard Free Skin and Cancer Hospital, *Theresa and Washington Avenues, St. Louis, Mo.*

Smith, Grafton Elliot, M.A., M.D., F.R.S., Professor of Anatomy, *The University, Manchester, England.*

Smith, H. P., A.B., Student of Medicine, *University of California, Berkeley, Calif.*

Smith, J. Holmes, M.D., Professor of Anatomy, University of Maryland, *Greene and Lombard Streets, Baltimore, Md.*

Smith, M. DeForest, A.B., M.D., Assistant in Neurology, Columbia University, *437 West 59th Street, New York City.*

Smith, Philip Edward, M.S., Ph.D., Instructor in Anatomy, *University of California, 1918 Haste Street, Berkeley, Calif.*

Smith, Wilbur Cleland, M.D., Assistant Professor of Anatomy, *Tulane University, New Orleans, La.*

Snow, Perry G., A.B., M.D., Professor of Anatomy, *University of Utah, Salt Lake City, Utah.*

Spitzka, Edward Anthony, M.D., *63 East 91st Street, New York, N. Y.*

Steensland, Halbert Severin, B.S., M.D., Professor of Pathology and Director of the Pathological Laboratory, College of Medicine, Syracuse University, *309 Orange Street, Syracuse, N. Y.*

Stewart, Chester A., A.M., Assistant in Anatomy, *University of Minnesota, Minneapolis, Minn.*

Stiles, Henry Wilson, M.D., Professor of Anatomy, College of Medicine, Syracuse University, *309 Orange Street, Syracuse, N. Y.*

Stockard, Charles Rupert, M.S., Ph.D. (Secretary-Treasurer '14–), Professor of Anatomy, *Cornell University Medical College, New York, N. Y.*

Stotsenburg, James M., M.D., Instructor in Anatomy, *Wistar Institute of Anatomy and Biology, Philadelphia, Pa.*

Streeter, George L., A.M., M.D., Research Associate in Embryology, Carnegie Institution, *Johns Hopkins Medical School, Baltimore, Md.*

Stromsten, Frank Albert, D.Sc., Assistant Professor of Animal Biology, University of Iowa, *943 Iowa Avenue, Iowa City, Iowa.*

Strong, Oliver S., A.M., Ph.D., Instructor in Anatomy, Columbia University, *437 West 59th Street, New York, N. Y.*

Strong, Reuben Myron, A.M., Ph.D. (Ex-Com. '16–), Associate Professor of Anatomy, Medical Department of Vanderbilt University, *Vanderbilt West Campus, Nashville, Tenn.*

Sundwall, John, Ph.D., M.D., Professor of Anatomy, *University of Kansas, Lawrence, Kans.*

Sutton, Alan Callender, A.B., Student, *Johns Hopkins Medical School, Baltimore, Md.*

Symington, Johnson, M.D., F.R.C.S., F.R.S., Professor of Anatomy, *Queens University, Belfast, Ireland.*

Swift, Charles H., M.D., Ph.D., Instructor in Anatomy, *Department of Anatomy, University of Chicago, 5632 Maryland Avenue, Chicago, Ill.*

Swindle, Gaylord, Ph.D., Instructor in Anatomy, *Washington University Medical School, St. Louis, Mo.*

Taintor, F. J., M.D., Assistant Professor of Anatomy, *St. Louis University, St. Louis, Mo.*

Taylor, Edward W., A.M., M.D., Assistant Professor of Neurology, Harvard Medical School, *457 Marlboro Street, Boston, Mass.*

Terry, Robert James, A.B., M.D. (Ex. Com. '08–'12), Professor of Anatomy, *Washington University Medical School, St. Louis, Mo.*

Thompson, Arthur, M.A., M.B., LL.D., F.R.C.S., Professor of Anatomy, *University of Oxford, Department of Human Anatomy, Oxford, England.*

Thorkelson, Jacob, M.D., *Dillon, Mont.*

Thro, William C., A.M., M.D., Assistant Professor of Clinical Pathology, Cornell University Medical School, *28th Street and 1st Avenue, New York, N. Y.*

Thüringer, Joseph M., M.D., Professor of Anatomy, *University of Alabama, School of Medicine, Mobile, Ala.*

Thyng, Frederick Wilbur, Ph.D., Assistant Professor of Anatomy in the University and Bellevue Hospital Medical College, *338 East 26th Street, New York, N. Y.*

Tilney, Frederick, A.B., M.D., Professor of Neurology, Columbia University, *161 Henry Street, Brooklyn, N. Y.*

Tobie, Walter E., M.D., Professor of Anatomy, *Bowdoin Medical School, 3 Deering Street, Portland, Me.*

Todd, Thomas Wingate, M.B., Ch.B. (Manc.), F.R.C.S. (Eng.), Professor of Anatomy, *Medical Department Western Reserve University, Cleveland, Ohio.*

Tracy, Henry C., A.M., Ph.D., Professor of Anatomy, Marquette Medical School, *Fourth and Reservoir Streets, Milwaukee, Wis.*

Tupper, Paul Yoer, M.D., Clinical Professor of Surgery, Washington University Medical School, *Wall Building, St. Louis, Mo.*

Turner, C. L., B.A., M.A., Instructor in the Department of Anatomy and Biology, *Marquette University School of Medicine, Milwaukee, Wis.*

Waite, Frederick Clayton, A.M., Ph.D., Professor of Histology and Embryology, Western Reserve University School of Medicine, *1353 East 9th Street, Cleveland, Ohio.*

WALKER, GEORGE, M.D., Instructor in Surgery, *Johns Hopkins University, corner Charles and Center Streets, Baltimore, Md.*

WALLIN, IVAN E., B.S., M.A., Assistant Professor of Anatomy, *Marquette University Medical College, Milwaukee, Wis.*

WARREN, JOHN, A.B., M.D., Associate Professor of Anatomy, *Harvard Medical School, 240 Longwood Avenue, Boston, Mass.*

WATERSTON, DAVID, M.A., M.D., F.R.C.S.Ed., Butte Professor of Anatomy, *University of St. Andrews, St. Andrews, Fife, Scotland.*

WATKINS, RICHARD WATKIN, B.S., Assistant in Anatomy, *University of Chicago, Chicago, Ill.*

WATT, JAMES CRAWFORD, B.A., M.B., Lecturer in Anatomy, *University of Toronto, 20 Hawthorne Avenue, Toronto, Canada.*

WEED, LEWIS HILL, A.M., M.D., Associate in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

WEIDENREICH, FRANZ, M.D., a.o. Professor and Prosector of Anatomy, *19 Vogesen Street, Strassburg, i. Els. Germany.*

WERBER, ERNEST I., Ph.D., Sessel Research Fellow, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

WEST, CHARLES IGNATIUS, M.D., Associate Professor of Anatomy, Medical Department of Howard University, *924 M Street N. W., Washington, D. C.*

WEST, P. A., B.A., *Johns Hopkins Medical School, Baltimore, Md.*

WEST, RANDOLPH, A.M., Student, College of Physicians and Surgeons, Columbia University, *437 West 59th Street, New York, N. Y.*

WHEELDON, THOMAS FOSTER, A.B., A.M., Austin Teaching Fellow, Department of Anatomy, *Harvard Medical School, Boston, Mass.*

WHEELER, THEODORA, A.B., M.D., *Carnegie Institute of Embryology, Wolfe and Madison Streets, Baltimore, Md.*

WHITE, HARRY OSCAR, M.D., Professor of Anatomy, Histology and Embryology, Medical Department, University of Southern California, *516 E. Washington Street, Los Angeles, Calif.*

WHITTENBORG, A. H., M.D., Professor of Gross-Anatomy, *College of Medicine, University of Tennessee, Memphis, Tenn.*

WILDER, HARRIS HAWTHORNE, Ph.D., Professor of Zoölogy, Smith College, *27 Belmont Avenue, Northampton, Mass.*

WILLIAMS, JAMES WILLARD, B.A., M.A., Professor of Biology, College of Yale in China, Changsha, China. (*Care of G. H. Malone, Nanking, China.*)

WILLIAMS, STEPHEN RIGGS, A.B., Ph.D., Professor of Zoölogy and Geology, Miami University, *300 East Church Street, Oxford, Ohio.*

WILLARD, WILLIAM A., A.M., Ph.D., Professor of Anatomy, *University of Nebraska, College of Medicine, 42d Street and Dewey Avenue, Omaha, Neb.*

WILSON, J. GORDEN, M.A., M.B., C.M. (Edin.), Professor of Otology, Northwestern University Medical School, *2437 Dearborn Street, Chicago, Ill.*

WILSON, JAMES THOMAS, M.B., F.R.S., Challis Professor of Anatomy, *University, Sydney, Australia.*

Wilson, Louis Blanchard, M.D., Director of Pathologic Division, Mayo Clinic and Mayo Foundation, Professor of Pathology in the University of Minnesota, *Mayo Clinic, Rochester, Minn.*

Wislocki, George Bernays, A.B., Student, *Johns Hopkins Medical School, Baltimore, Md.*

Witherspoon, Thomas Casey, M.D., *307 Granite Street, Butte, Mont.*

Worcester, John Locke, M.D., Instructor in Anatomy, University of Michigan, *1123 Michigan Avenue, Ann Arbor, Mich.*

PROCEEDINGS OF THE AMERICAN SOCIETY OF ZOOLOGISTS

FOURTEENTH ANNUAL MEETING

The American Society of Zoologists held its fourteenth Annual Meeting jointly with Section F of the American Association for the Advancement of Science and in affiliation with the American Society of Naturalists, December 27, 28 and 29, 1916, in Schermerhorn Hall, Columbia University, New York City.

BUSINESS SESSION

Election of Members

At the session for transacting business, held at 11 o'clock on Friday, December 29, President D. H. Tennent in the chair, the persons whose names follow, having been recommended by the Executive Committee to the Society for election to membership, we duly elected.

Allen, Ezra, A.M., Ph.D. (University of Pennsylvania), Professor of Biology, *Philadelphia School of Pedagogy, 12th above Spring Garden, Philadelphia, Pa.*

Carothers, E. Eleanor, A.B., A.M., Ph.D., *Zoological Building, University of Pennsylvania, Philadelphia, Pa.*

Churchill, Edward Perry, A.B. (Iowa), Ph.D. (Johns Hopkins), Assistant U. S. Bureau of Fisheries, *317 Marshall Street, Hampton, Va.*

Cort, William Walter, A.B. (Colorado College), M.A., Ph.D., University of Illinois), Assistant Professor of Zoology, University of California, *Department of Zoology, University of California, Berkeley, Calif.*

Dolley, Jr., William Lee, A.B., A.M. (Randolph-Macon), Ph.D. (Johns Hopkins), Professor of Biology, *Randolph-Macon College, Ashland, Va.*

Gee, Wilson, B.S. (University of S. C.), Ph.D. (University of California), Professor of Biology, *Emery University, Oxford, Ga.*

Goodrich, Hubert Baker, B.S. (Amherst), M.A., Ph.D. (Columbia), Instructor in Zoology, *Wesleyan University, Middletown, Conn.*

Hall, Maurice Crowther, S.B., M.A., Ph.D., D.V.M., Parasitologist, *Research Laboratory, Parke, Davis & Co., Detroit, Mich.*

Ibsen, Heman Lawritz, B.S., M.D., Ph.D. (Wisconsin), Assistant in Experimental Breeding, *University of Wisconsin, Madison, Wis.*

JONES, ORREN LLOYD, B.S., M.S., Ph.D. (Wisconsin), Associate Professor, Animal Husbandry, *Iowa State College, Ames, Iowa.*

KINCAID, TREVOR, M.S., Professor of Zoology, *University of Washington, Seattle, Wash.*

METZ, CHARLES W., B.A., Ph.D., Station for Experimental Evolution, *Carnegie Institution of Washington, Cold Spring Harbor, Long Island, N. Y.*

MIDDLETON, AUSTIN RALPH, A.B., Ph.D. (Johns Hopkins), Assistant Professor of Biology, *University of Louisville, Louisville, Ky.*

MOSHER, EDNA, B.S. (Cornell), Ph.D. (Illinois), Instructor in Entomology, *University of Illinois, Natural History, Building, Urbana, Ill.*

MULLER, HERMAN J., A.M., Ph.D., Instructor in Zoology, *Rice Institute, Houston, Texas.*

PACKARD, CHARLES, M.S., Ph.D., Instructor in Zoology, Columbia University, *Schermerhorn Building, Columbia University, New York City.*

ROBERTSON, WILLIAM R. B., A.B. (Kansas), Ph.D. (Harvard), Assistant Professor of Zoology, University of Kansas, *1420 Ohio Street, Lawrence, Kans.*

ROGERS, FRED TERRY, A.B., Ph.D. (Chicago), Assistant Professor of Zoology, *Baylor University, Waco, Texas.*

SHEPHERD, W. T., A.M., Ph.D., Professor of Zoology and Dean, *Waynesburg College, Waynesburg, Pa.*

VAN CLEAVE, HARLEY JONES, B.S., (Knox College), M.S., Ph.D. (Illinois), Associate in Zoology, *300 Natural History Building, Urbana, Ill.*

WENRICH, DAVID HENRY, B.A., M.A., Ph.D., Instructor in Zoology, *University of Pennsylvania, Zoological Laboratory, Philadelphia, Pa.*

WENTWORTH, EDWARD N., M.S. (Iowa), Professor of Animal Husbandry, *Kansas State Agricultural College, Manhattan, Kans.*

WHITING, PHINEAS W., A.B., M.S., Ph.D., Harrison Research Fellow, *University of Pennsylvania, Zoological Laboratory, Philadelphia, Pa.*

Election of Officers

The Committee on Nominations, consisting of E. A. Andrews, Edwin Linton and C. A. Kofoid, having recommended persons for election to the various offices of the Society, and no other nominations having been made, Maynard Mayo Metcalf was elected President to serve for one year, Charles Zeleny, Vice-President to serve for one year, Caswell Grave, Secretary-Treasurer to serve three years, and H. V. Wilson, Member at large of the Executive Committee to serve five years.

Report of the Secretary-Treasurer

The Secretary-Treasurer reported that 40 members withdrew from the Society during the year and that 26 members have not paid dues, in protest against the increase in annual dues, but that

257 members have accepted the plan, adopted at the Columbus meeting, for supporting and increasing the circulation of Journals published by The Wistar Institute. Attention was called to the fact that the list of members of the Society now contains 308 names of which 173 (56 per cent) are of members residing in Eastern territory, 135 (44 per cent) are of members residing in Western territory.

Financial Statement

The financial statement of the Secretary-Treasurer, for the year 1916, is as follows:

RECEIPTS

January 1, 1916:	
Balance on hand	809.68
Back dues for the year 1913	2.00
Back dues for the year 1914	8.00
Back dues for the year 1915	36.00
January to December:	
Dues for 1916 at $11.50	126.50
Dues for 1916 at 8.00 (Foreign)	8.00
Dues for 1916 at 7.00	1225.10
Dues for 1916 at 6.50 (Life Members)	19.50
Dues for 1916 at 6.00	6.00
Dues for 1916 at 5.00	335.10
October 1, 1916:	
Interest at 4 per cent on deposits	32.61
Total	$2608.49

EXPENDITURES

January to December:	
Appropriation for Councilium Bibliographicum	200.00
Express charges	4.35
Telegraph, telephone and street car	2.60
Two copies "Science" containing Proceedings	.30
Stationery, stamps, post-cards	32.82
Typewriting and clerical assistance	31.65
Printing announcements and programs	51.55
Overpaid dues returned to H. F. O.	5.00
257 subscriptions for Journals, Wistar Inst.	1591.00
Expenses of Secretary at Conference on Journals	4.80
Expenses of Secretary at New York meeting	34.84
Total	$1958.91
December 28, 1916:	
Balance on hand	$649.58

Report of Auditing Committee

The Auditing Committee, consisting of Ulric Dahlgren and William H. Longley, reported that the accounts of the Secretary-Treasurer had been examined and found correct.

Instruction for Executive Committee

By motion made by P. P. Calvert, seconded by C. E. McClung, the Society instructed its Executive Committee to continue to make efforts to increase the number and variety of Journals available to members in return for annual dues.

Change in By-Laws

By vote of the Society, by-law 4 b, which reads as follows; was stricken from the list of by-laws.

4(b) When the annual meeting is held in conjunction with the American Society of Naturalists, the Society shall adjourn for one session (morning or afternoon) to meet in joint session with the American Society of Naturalists, and it shall be the policy of the Society to conclude its annual meeting with the Naturalists' dinner, and the Secretary-Treasurer is instructed to urge upon the Naturalists the propriety of adjusting their program with this point in view.

Resolution Adopted

E. G. Conklin proposed the following resolution which was unanimously adopted by the Society:

"*Whereas*, the National Academy of Sciences has, at the request of the President of the United States, organized the National Research Council for the purpose of promoting and organizing research in the interest of National Welfare, and

"*Whereas*, we recognize that human progress is dependent upon the advancement of knowledge, and

"*Whereas*, one of the chief purposes of the American Society of Zoologists is the promotion of research in Zoology,

"*Therefore*, be it resolved that the American Society of Zoologists agrees to cooperate with the National Research Council in any ways practicable."

Committee on Premedical Education

The Committee on Premedical Education, failing again to submit a report, was continued and instructed to report at a future meeting.

JOINT SESSION WITH NATURALISTS

The business of the Society having been transacted, the session adjourned to meet in joint session with the American Society of Naturalists, at 2 p.m., in the Horace Mann School, the program for which was a symposium on the subject, "Biology and National Existence."

Sessions for Presentation and Discussion of Papers

At sessions held during the forenoons and afternoons of December 27 and 28 and during the first part of the forenoon session on December 29, the papers listed on the program were read in full or by title. Forty-four papers were presented in full, twenty-seven were read by title. The papers listed in the Genetics Section, as ordered by the Society at the Columbus Meeting, were scheduled for and read at the session on the afternoon of December 28.

TITLES OF PAPERS

LIST OF TITLES OF PAPERS ARRANGED IN GROUPS IN THE ORDER RECEIVED BY THE SECRETARY

COMPARATIVE ANATOMY

1. Cell inconstancy in Hydatina senta. A. Franklin Shull, University of Michigan.
2. A gynandromorphous cat. Mary T. Harmon, Kansas State Agricultural College.
3. On the third layer of protoplasm in amoeba. A. A. Schaeffer, University of Tennessee.
4. Some homologies in the epipharynx and hypopharynx of the nematocerous diptera. Adelbert L. Leathers, Olivet College (Section F).

EMBRYOLOGY

5. The history of the eye muscles. (Lantern illustrations.) H. V. Neal, Tufts College.
6. A case of superfetation in the cat. Mary T. Harmon, Kansas State Agricultural College.
7. On the mechanism of serial differentiation in the embryonic vertebrate nervous system. O. C. Glaser, University of Michigan.
8. Embryology of the yellow mouse. W. B. Kirkham, Yale University.
9. Investigations of the light organs of arthropods. Ulrich Dahlgren, Princeton University.
10. Further experiments on the laterality of transplanted limbs. Ross G. Harrison, Yale University.
11. The effect of removal and regeneration of parts upon metamorphosis in amphibian larvae. Charles Zeleny, University of Illinois.
12. Life history of Zeugophora scutellaris. B. H. Grave, Knox College.
13. The results of extirpation of the hypophysis and thyroid glands of Rana. Bennet M. Allen, University of Kansas.

CYTOLOGY

14. An experimental study of cell division. L. V. Heilbrun, University of Illinois College of Medicine.
15. Early castration of the vertebrate embryo. Franklin P. Reagan, Princeton University. Introduced by C. F. W. McClure.
16. Microdissection studies. The cell aster; a reversible gelation phenomenon.—Illustrated with drawings. Robert Chambers, Jr. Cornell University Medical College.
17. Multiple chromosomes of Hesperotettix and Mermiria. C. E. McClung, University of Pennsylvania.
18. The spermatogenesis of Culex pipiens, P. W. Whiting, University of Pennsylvania. (Section F.)
19. The segregation and recombination of homologous chromosomes in two genera of Acrididae (Orthoptera). E. Eleanor Carothers, University of Pennsylvania. (Section F).
20. Synapsis and chromosome organization in the male germ cells of Chortippus and Trimerotropis. D. H. Wenrich, University of Pennsylvania. (Section F).
21. The chromosome complex in Apithes agitator. W. J. Baumgartner, University of Kansas.

22. New facts and views concerning the occurrence of a sexual process in the life cycle of a myxosporidia, chloromyxum leydigi. Rhoda Erdmann, Yale University.
23. Spermatogenesis in the albino rat. Ezra Allen, University of Pennsylvania. (Section F).
24. Multiple complexes in the alimentary tract of Culex pipiens. Caroline M. Holt, University of Pennsylvania. (Section F).

GENETICS

25. Sex-linked inheritance of spangling in poultry. George Lefevre, University of Missouri.
26. Two classes of factors for color patterns in Paratettix. Robert K. Nabours, Kansas State Agricultural College.
27. The relation of yellow coat color to black eyed white spotting of mice, in heredity. C. C. Little, Harvard Medical School.
28. Mutation in Didinium nasutum. S. O. Mast, Johns Hopkins University.
29. The occurrence of mutations in skunks of the species, Mephitis putida and M. hudsonica. J. A. Detlefsen, University of Illinois, College of Agriculture.
30. The influence of parental alcoholism on the learning capacity of the offspring. E. C. MacDowell, Carnegie Institution of Washington.
31. Linkage in the sex-chromosome of a new species of Drosophila. Chas. W. Metz, Carnegie Institution of Washington. Introduced by C. B. Davenport.
32. An examination of the so-called process of contamination of Genes. Thomas Hunt Morgan, Columbia University.
33. An analysis of the effect of selection on bristle number in a mutant race of Drosophila. Alfred H. Sturtevant, Columbia University.
34. The elimination of males in alternate generations of sex-controlled lines. Calvin W. Bridges, Columbia University. Introduced by T. H. Morgan.
35. Coincidence of crossing over and the chromosome theory of linkage. Alexander Weinstein, Columbia University. Introduced by T. H. Morgan.
36. Determinate and indeterminate laying cycles in birds. Illustrated with lantern. L. J. Cole, University of Wisconsin.
37. A strain of sex intergrades. Arthur M. Banta, Carnegie Institution of Washington.
38. Effect on fertility of crossing closely and distantly related stocks of Drosophila ampelophila. Roscoe R. Hyde, Indiana State Normal School.
39. Are the polyradiate cestodes mutations? Illustrated with lantern. Franklin D. Barker, University of Nebraska.

EVOLUTION

40. A revised working hypothesis of mimicry. W. H. Longley, Goucher College.

COMPARATIVE AND GENERAL PHYSIOLOGY

41. Recent studies of nerve conduction in Cassiopea. Illustrated with lantern. Alfred G. Mayer, (Carnegie Institution of Washington).
42. The theory of sex as stated in terms of results of studies on the pigeons. Oscar Riddle, Carnegie Institution of Washington.
43. The adaptive color changes of tropical fishes. Illustrated with lantern. W. H. Longley, Goucher College.
44. The histological basis of adaptive shades and colors in the flouder, Paralichthys albiguttus. Albert Kuntz, St. Louis University School of Medicine.
45. Further data on the relation between the gonads and the soma of some domestic birds. H. D. Goodale, Massachusetts Agricultural Experiment Station.
46. The sensory potentialities of the nudibranch Rhinophores. Leslie B. Arey, Northwestern University Medical School.

47. Paramecium grown in pure cultures of bacteria. George T. Hargitt and Walter W. Fray, Syracuse University.
48. Recognition among insects. N. E. McIndoo, Bureau of Entomology.
49. The rate of locmotion of Vanessa antiopa in different luminous intensities and its bearing on the "Continuous Action theory of Orientation." Wm. L. Dolley, Jr., Randolph-Macon College. Introduced by S. O. Mast.
50. A super-organ for the expansion of Renilla. G. H. Parker, Harvard University.
51. The photoreceptors of Amphioxus. W. J. Crozier, Bermuda Biological Station.
52. The olfactory reactions of snails. Manton Copeland, Bowdoin College.
53. The reactions of the crimson-spotted newt, Diemyctylus viridescens to light. Albert M. Reese, West Virginia University.
54. Reaction of the whip-tail scorpion to light. Bradley M. Patten, Western Reserve University.
55. The effect of light and dark upon the eye of prorhynchus applanatus, Kennel. W. A. Kepner, and A. M. Foshee, University of Virginia.
56. Experimental control of endomixis in Paramecium. R. T. Young, University of North Dakota.
57. Orientation to light in Planaria (n. sp.) and the function of the eyes. W. H. Taliaferro, Johns Hopkins University. Introduced by S. O. Mast.
58. Sense of taste in Nereis virens. Alfred O. Gross, Bowdoin College.
59. The Influence of the Marginal Sense Organs on Functional Activity in Cassiopea Xamachana, Bigelow. Lewis R. Cary, Princeton University.
60. The relation between the hydrogen ion concentration of sperm suspensions and their fertilizing power. Edwin J. Cohn, University of Chicago. Introduced by Frank R. Lillie.
61. Experimental study of ageing eggs and sperm and of their development. A. J. Goldfarb, College of the City of New York.
62. The consumption of oxygen during the development of Fundulus heteroclitus. George G. Scott, College of the City of New York, and William E. Kellicott, Goucher College.
63. A study of broodiness in the Rhode Island Red breed of domestic fowl. H. D. Goodale, Massachusetts Agricultural Experiment Station.
64. The vitalty of cysts of Didinium nasutum. S. O. Mast, Johns Hopkins University.
65. The reactions of Pelomyxa Carolinensis, Wilson, to food. W. A. Kepner and J. G. Edwards, University of Virginia.
66. The significance of conjugation and encystment in Didinium nasutum. S. O. Mast, Johns Hopkins University.

ECOLOGY

67. Some distributional problems of Okefinokee Swamp. A. H. Wright, Cornell University.

PARASITOLOGY

68. A means of transmitting the fowl nematode, Heterakis papillosa (Bloch). James E. Ackert, Kansas State Agricultural College.
69. Further studies on changes in Thelia bimaculata brought about by insect parasites. Illustrated with lantern. S. I. Kornhauser, Northwestern University.
70. Some experiments on the transmission of swamp fever by insects. Illustrated with lantern. John W. Scott, University of Wyoming.
71. The domestic cat a host of taenia pisiformis (Bloch). James E. Ackert, Kansas State Agricultural College.

DEMONSTRATIONS

1. Preparations showing the structure of a transformed plasma Clot. George A. Baitsell, Yale University.

2. Demonstrations of the following types of chromosome groups in Drosophila ampelophila, XX (female), XY (male), XXY (female), XXYY (female). Calvin W. Bridges, Columbia University.
3. The innervation of the vertebrate digestive tube (Methylene blue intravitam staining) F. W. Carpenter, Trinity College.
4. The phosphorescence of enteropneusta. W. J. Crozier, Bermuda Biological Station.
5. The relation between the gonads and the secondary sexual characters in birds. H. D. Goodale, Massachusetts Agricultural Experiment Station.
6. Mounted skins showing a new color variety of the Norway rat. Helen D. King and P. W. Whiting, University of Pennsylvania.
7. Photographs of Thelia illustrating the changes brought about by the parasitic hymenopteron Aphelopus. S. I. Kornhauser, Northwestern University.
8. Multiple chromosomes of Hesperotettix and Mermiria. C. E. McClung, University of Pennsylvania.
9. Models and specimens showing transplanted limbs. Ross G. Harrison, Yale University.
10. Miscropic slides illustrating spermatogenesis in Culex pipiens. P. W. Whiting, University of Pennsylvania. (Section F).
11. Specimens of Polyradiate cestodes. Franklin D. Barker, University of Nebraska.

1. Cell inconstancy in Hydatina senta. A. Franklin Shull, University of Michigan.

The number of cells in the various organs of this rotifer was reported by Martini to be always the same. In at least two organs, however, it is found that in a small percentage of individuals aberrant numbers occur. This inconstancy is more in keeping with the well established variability and modifiability of the life cycle.

2. A Gynandromorphous cat. Mary T. Harmon, Kansas State Agricultural College.

A cat having an ovary on the right side and a testis on the left, was discovered in our laboratories last winter. The animal had been skinned and partially dissected before its peculiarity was discovered. The scrotal sac and external genitalia had been removed.

The testis which is about the size and shape of a navy bean is entirely on the outside of the body cavity ventrad and to the left of the ventral border of the pubis. It has all the appearance of a normal testis. The spermatic cord extends from the testis through the oblique muscle where it divides into the vas deferens and the spermatic vein and artery. The vas deferens extends anteriorly until it curves over the ureter where it continues caudad dorsal to the neck of the urinary bladder. It pierces the prostate gland and enters the urethra about half way between the base of the urinary bladder and the exterior. The prostate gland of the left side is larger than the one of the right side although there seems to be a gland on the right side.

The ovary is located on the right side of the body a little posterior to the kidney. It is slightly smaller than the testis and is quite angular. Anterior to the ovary and partially surrounding it is the ostium tubae abdominale. The ovarian artery and the ovarian vein extend to the left from the ovary. Extending from the ostium tubae abdomi-

nale is the uterine tube which continues caudad almost parallel to the vas deferens. It enters the urethra through the abortive right prostate gland. The ovary and the uterine tube are held in place by the broad ligament and the round ligament.

3. On the third layer of protoplasm in ameba. A. A. SCHAEFFER, University of Tennessee.

In addition to the streaming endoplasm and the more or less stationary ectoplasm in amebas there is found a third layer separating the ectoplasm from the surrounding water. This third layer is extremely thin, probably too thin to be seen easily, but the existence of it can be readily demonstrated by means of the movement of small particles which occasionally attach themselves to it. The most striking feature of the movement of particles attached to this third layer is that *they move forward toward the tip of a pseudopod faster than the tip advances through the water.* Particles travel from every part of the surface toward the tips of the advancing pseudopods. If there is but one pseudopod, all the particles travel toward the tip of this pseudopod. The effect is therefore that all the particles tend to collect at the advancing end of the ameba. Most of the particles drop off however when or soon after they reach the front end of a pseudopod. Particles travel at varying speeds, depending upon where they are located; particles on an actively enlarging pseudopod move faster than those near the posterior end of the ameba. In a general way, the nearer they approach the tip of a pseudopod the faster the particles travel. The speed of a moving particle attached to the third layer is not directly affected by nor related to the rate of streaming of the endoplasm immediately under it (but separated from it, of course, by the ectoplasm). The granules in the streaming endoplasm of a pseudopod move considerably faster than the particles attached to the outside third layer. But occasionally one may see a particle sticking to the third layer move more rapidly than the slowly and uncertainly moving endoplasm immediately beneath it. When streaming is reversed in a pseudopod, movement in the third layer is likewise reversed, and frequently particles attached to the outside travel away from the tip of the retracting pseudopod more rapidly than the tip is retracted. These particles then move toward the tip of another advancing pseudopod. Occasionally a particle sticks so close that it travels all over an ameba before it finally drops off. This third layer is found in Amoeba proteus, A. discoides, A. dubia, A. vespertilio, and A. metaproteus (an undescribed species).

Whatever may be the relation of this third layer to endoplasmic streaming, it is clear that from the transportative aspect it is not an aid but a slight hindrance to locomotion, since the layer moves in the same direction as the ameba.

The nature of this layer is not clear. It seems to be in process of continual formation all over the ameba, and in process of continual destruction at the anterior ends of pseudopods. Surface is not therefore made at the advancing tips of the pseudopods, as might be thought

at first sight, but destroyed, i.e., converted into interior (non-surface) matter. Surface is made over the entire ameba, but very slowly at the posterior end and at the tips of retracting pseudopods. From inspection it appears that the layer is protoplasmic in composition rather than aqueous, though there is insufficient evidence at hand to decide definitely. It is also at this time impossible to state whether there is essential connection between locomotion and the movement of this third layer.

The pseudopods of Difflugia pyriformis carry foreign particles on their surfaces, but these particles do not move as rapidly as the tips of the pseudopods advance. Diatoms and Oscillatoria likewise carry particles on their surfaces, but in the latter the same agency that carries the particles also moves the Oscillatoria filaments. Whether the transportative agencies of these several organisms have anything in common cannot yet be stated.

4. Some homologies in the epipharynx and hypopharynx of the nematocerous diptera. ADELBERT L. LEATHERS, Olivet College, Section F.

The literature bearing on this subject is very incomplete and more or less confused. The 'lateral arms' or 'premandibles' of the hypopharynx have been well figured for only the Chironominae, while in the other families and subfamilies of the group no such structures have hitherto been recognized. These structures will be shown by a series of comparative figures with especial reference to the family Chironomidae, but will include one or more other families in less detail. In a similar manner the comparative development of the hypopharynx from a rudimentary structure to a highly developed tritrating organ will be compared.

5. The history of the eye muscles. H. V. NEAL, Tufts College. (With lantern illustrations.)

The attempt is made in this paper to demonstrate on the basis of embryological evidence the exact homology of the first three permanent myotomes of Amphioxus, Petromyzon, and Squalus and to describe the more important stages in the phylogenesis of the eye muscles.

The evidence is presented for the first time to support the assertion of Dohrn ('04) and the writer ('07) that the second as well as the third myotome participates in the formation of the external rectus muscle. In the light of the evidence given the familiar text-book formula for the ontogenesis of the eye muscles should be amended as follows:

From the first myotome (pre-mandibular head-cavity) arise the muscles innervated by the oculomotor, viz., the Mm. recti superior, internus, and inferior, and the M. obliquus inferior;

From the second myotome (mandibular head-cavity) develop the M. obliquus superior and the ventro-lateral portion of the M. rectus externus;

From the third myotome (hyoid head-cavity) arises the dorso-median portion of the M. rectus externus.

6. A case of superfetation in the cat. MARY T. HARMAN, Kansas State Agricultural College.

The gravid uterus of a cat had two enlargements of the right horn and three enlargements of the left horn. The enlargement of the right horn next to the ovary and the two enlargements of the left horn toward the ovary each contained an embryo 90 mm. in length exclusive of the tail. From the external features, they appear to be near to term. The limbs are well formed and normal, having joints and on the ends of the digits are claws. The whole surface of the skin is covered with pits but very little hair is present. The tail is more than one-third the length of the body. The fetal membranes fill the entire enlargement and fit very closely to its walls.

The enlargement of the right horn of the uterus next to the vagina contained an embryo only 10 mm. in length which seemed perfectly normal and which had no indications of having been dead long before it was preserved. The umbilical cord occupies about one-sixth of the ventral surface. The limbs both fore and hind, are merely buds. The tail is about one-fifth the length of the remainder of the body. There are no indications of hair. The mouth is in the process of formation. The mandibular processes have met in the median line; but they extend only about one-third as far as the maxillary processes. The lip groove is shallow, in fact, there is merely the beginning of the separation of the lips and cheeks from the jaw. The oral pit is rectangular in shape. There is no indication of eyelids; but the eyes are plainly visible from the outside as small dark spheres. This embryo does not seem to be of more than two weeks development.

If the size of the blood vessels of the uterus and the condition of the blood vessels to the embryos may be taken as a criterion, the blood supply to the small embryo is as good as to the large embryos. It seems as reasonable to the writer to think of the less advanced embryo as the result of delayed fertilization as to account for it on the ground of arrested development or of a second coition.

7. On the mechanism of serial differentiation in the embryonic vertebrate nervous system. O. C. GLASER, University of Michigan.

Long before the separation of the neural plate from the ectoderm is complete, the developing neural tube prefigures a serial differentiation that culminates in a succession of vesicles highly constant for the vertebrate nervous system and, as one of its basic attributes, calling for explanation.

More than forty years ago His attempted to account for the vesiculation of the embryonic brain in terms of cranial flexure. Substantiated by ingenious experiments with rubber models, this theory could account for the early lateral and ventral differentiations of the prospective interbrain. However, since the onset of vesiculation occurs before that of cranial flexure the view that the former is dependent upon the latter involves an anachronism.

According to His cranial flexure and the subsequent rearrangement of the vesicles are the outcome of differential growth which produces a state of compression in the antero-posterior axis. It is obvious that such compression, if demonstrable prior to cranial flexure, would necessarily be an important element in helping us to understand how the nervous system has imposed upon it its characteristic form.

Compression in the antero-posterior axis cannot be demonstrated by the method used by His. It can, however, be shown to exist by comparing the length of the embryonic head with that of the nervous system. The relation between these two measurements can be expressed in the form of a fraction derived by dividing half the perimeter of the nervous system into the head length. This fraction, which I have called the neurocephalic quotient, tells how many units of head-length are available for every unit of length in the nervous system.

When the quotient is greater than unity, the nervous system cannot be under compression; when it is less than unity, a state of compression must exist. A priori we should expect high quotients in the earlier stages and low quotients in the later, whereas embryos in which the vesicles are telescoped or abnormally overdifferentiated, should have quotients lower than normal for their respective ages.

These expectations, as will be shown in the paper, are fulfilled, and the conclusion seems warranted that a rising state of compression in the longitudinal axis, prior to cranial flexure, is one of the important conditions under which the vesiculation of the embryonic brain takes place.

The paper will be fully illustrated by tables, drawings, and a curve.

8. Embryology of the yellow mouse. W. B. Kirkham, Osborn Zoological Laboratory, Yale University.

It has for some years been known to breeders that yellow mice did not breed true to coat color, each litter almost always containing one or more young of a color other than yellow, and it has also been found that the average number of young in a litter is smaller from yellow than from other colors of mice. These two observed facts taken together have given rise to the theory that all the available yellow mice are heterozygous as regards coat color, and that the homozygous zygotes which should theoretically exist are for some reason not viable. To test out this theory has been the purpose of this work.

Material from non-suckling yellow mice, representing each of the first nineteen days of pregnancy has been assembled, that for the first three days comprising ovaries and Fallopian tubes, that for stages beyond the third day the uteri as well as the ovaries and tubes. The entire material from each mouse has been sectioned, mounted, stained, and every section examined, while all the embryonic stages found have been compared with those of like age from non-suckling white mice. The results are as follows:

(a) The rate of cleavage and of embryonic development is the same for yellow as for white mice.

(b) All of the observed two-cell stages of both yellow and white mice appear normal.

(c) No degenerating morulae or blastulae were found in white mice, while one or more were present in every yellow mouse containing embryos of that stage in development.

(d) The material covering the sixth to the seventeenth days of pregnancy has yielded degenerating embryos in eight uteri out of twenty-eight in white mice, and in eleven out of thirteen in yellow mice. If we eliminate females who, by having still births or by eating up their new-born young, showed themselves abnormal, the figures become more striking, degenerating embryos in white mice appearing only in one uterus out of the twelve examined, while in yellow mouse uteri eleven out of twelve contained them.

(e) After the normal time for implantation (sixth day of pregnancy) all the degenerating embryos found, with one exception, had induced a typical reaction on the part of the uterine mucosa, but had themselves failed to undergo any development beyond the blastula stage.

(f) No degenerating embryos have been found in either white or yellow mice pregnant more than sixteen days. This is to be expected, as the evidence all indicates that if degeneration is going to take place it starts before the seventh day of pregnancy, and the embryos are then so small that the phagocytes easily remove them, and the uterine wall in their vicinity returns to its resting condition several days before the normal embryos are born.

(g) Mendel's law requires an average of 25 per cent homozygous yellow offspring from heterozygous yellow parents. In this investigation we have found in normal yellow females, six to seventeen days pregnant, 69 embryos, of which 26 or 37.8 per cent were degenerating, as contrasted with 2 degenerating embryos out of a total of 84, or 2.3 per cent obtained from normal white females pregnant for the same period of time.

Conclusion. The evidence produced by this investigation is not as absolutely decisive as might be hoped for, but the much greater percentage of degenerating embryos in yellow mice than in white would indicate that some at least of these degenerating yellow mouse embryos are the missing homozygous animals.

9. Investigations of the light organs of arthropods. Ulrich Dahlgren, Princeton University.

The origin of the imaginal light organs in Photorus pennsylvanica was investigated to find out how it was derived during the pupal stage. Larvae, bearing their two round ventro-lateral organs on the penultimate segment, were collected in the spring and placed in vivaria containing soil and dead leaves from their habitat. In latter May these larvae scooped shallow cavities in the ground, built lattice-shaped covers with a mixture of saliva and clay and became torpid. In a few days the skin was shed and the cream-white pupae lay in the cavities when they could be easily observed after breaking off the clay covers and

placing loose leaves over the nest. Eight to eleven days at the prevailing temperature saw them change into the adult fly. During this time a series of successive browning and blackening of different parts of the underlying integument of the imago marked their gradual development and gave a series of marks to establish a correct chronology upon which to establish the successive stages of the metamorphosis of the light organs. At first only the two larval organs showed. They were always ready to light up on stimulation until about half way through the change when they lost the power for about twenty-four hours. At about this time the adult organs began to appear as whitened surfaces of the same segment that contained the larval light organ and also that segment immediately anterior to it. At about the sixth or seventh day this new surface began to light in a central spindle-shaped area in each side of the two segments and the lighting power spread out from these focii until shortly before hatching when the entire surfaces would light slowly if the pupae was disturbed in any way.

The internal changes accompanying this were briefly as follows; the small round larval organs began at an early date to be retired from their position against the cuticle and when the imaginal cuticle was formed the entire surface was lined by a hypodermis that showed no differentiation. Signs of histolysis became evident in the larval organ which had moved far in toward the center of the body. The new imaginal centers of the adult organs now showed a deposit of large, yolk-like granules in these cells. The new ventral hypodermis of the imaginal light segments also showed this accumulation of reserve food material as scattered pupal yolk globules.

Shortly afterward the hypodermis proliferated into several layers which grew rapidly into the light cells.

The origin of the reflector layer is somewhat obscure but appears to be a differentiation of the dorsal portion of these epithelial-derived cells. The trachae grow in and form the cylinders and the end cells appear just before hatching. The light organs of the Lampyridae are not developed from the fat organs as many authors have surmised but from the ventral integumental epithelium of the insect.

The luminous organs of the ostracod, Cypridina hilgendorfii, was also studied. Müller has already shown that light glands opened in several places on the upper lip of a closely allied, if not the same, form. Doflein undertook to study the organ more closely and was much at fault in his description. He described and drew a sac-shaped reservoir opening at the upper lip by several apertures. The luciferine was secreted by a large gland forming a part of the fundus of the sac. Doflein undoubtedly drew the brain or supra-esophageal ganglion for this gland as Yatsu pointed out to Dr. E. N. Harvey and as the writer concluded from reading the article and examining the drawing.

Studies of the organ in some beautifully preserved material from Japan collected for the writer by Dr. E. N. Harvey show the following conditions: The luminous organ consists of a group of from twenty to

thirty hypodermal cells invaginated from the edge of the upper lip into an elongate series of unicellular glands that reach up to and almost touch the upper brain ganglia. These cells are arranged bilaterally into two contiguous groups. They may be distinguished as of three different kinds by their secretion and form. The first two kinds secrete a series of granules that are basic in reaction, taking the acid dyes as eosin. One of these secretes a very large heavy weaker staining granule and the other a very small deeper staining granule. The cytoplasmic bodies of these cells form a compact rounded mass up near the brain. They show large single nuclei each with a very large central plasmosome.

The distal part of each cell reaches down to the median part of the upper lip and open through the chiten as a very short papillae. This distal region forms in each case a long hollow tube filled closely with the granules of the cell. It is possible that two cells sometimes open through a single papillae but it is not probable. The papillae are closely set together in a group.

The third kind of cells form a wide shallow common sac on each side of this median group. Their cytoplasmic bodies are united into the upper wall of this sac which serves as a common reservoir for the secretion. While shallower than in the case of the first cells, the cytoplasm of these third cells is of the same texture and holds the same kind of nucleus but its secretion is totally different, being much like mucous and staining the opposite (with the chromatin stains) of that of the first two kinds. There are two of these sacs and each opens through a very long slender papilla that hangs down laterally to the opening of the typical ostracod shell.

A peculiar point is that one of the coarse granular cells on each side sends its distal end or duct into this long papilla and opens alongside of the sac duct by a separate but closely approximated opening.

10. Further experiments on the laterality of transplanted limbs. Ross G. Harrison, Osborn Zoological Laboratory, Yale University.

Additional experiments with the fore limb bud of Amblystoma embryos make it possible to state more simply than before the rules governing the laterality of transplanted limbs (Proc. Am. Assoc. Anat., Anatom. Rec., vol 10, 1916).

Limb buds were transplanted either to their natural location after removal of the normal bud (orthotopic transplantation), or to another region of the body, as for instance to the flank between the fore and hind limbs (heterotopic transplantation). They were grafted either on the same (homopleural) or on the opposite (heteropleural) side of the body, and were placed either in the upright (dorso-dorsal) or the inverted (dorso-ventral) position.

The following rules underlie the determination of the laterality of the appendages which develop out of the transplanted buds in both the orthotopic and heterotopic transplantations, though in the former

the limbs are more likely to be modified through the influence of their more normal surroundings (vascularization, innervation, etc.).

Rule 1. A bud that is not inverted (dorso-dorsal) retains its original laterality whether implanted on the same or on the opposite side of the body.

Rule 2. An inverted bud (dorso-ventral) has its laterality reversed whether implanted on the same or on the opposite side.

Rule 3. When double or twin limbs arise, as is frequently the case in these experiments, the original of the two limbs, i.e., the one first to begin its development, has its laterality fixed in accordance with the above rules, while the other is the mirror image of the first.

In heterotopic transplantations abortive development, or even complete absorption of the tissue, often takes place, and reduplication may occur in any of the combinations.

In the orthotopic series abortive development is more rare and reduplications, though frequent, are limited to certain combinations and may be further modified. The outcome in the several groups of experiments was as follows:

1. Homopleural dorso-dorsal grafts developed normally though at first very slightly retarded.

2. Homopleural dorso-ventral grafts resulted in:

a. A single limb of reversed laterality (structurally and functionally perfect right limb on left side). One case only.

b. Reduplicated limbs. More than half of the cases.

c. Typical non reversed limbs which began their development by growing in abnormal direction, but ultimately assumed normal posture by rotation. These cases form the only exception to the rules and require further investigation.

3. Heteropleural dorso-dorsal transplantations yielded:

a. Single non reversed limbs. Two cases only, neither perfect.

b. Reduplicated limbs in which the secondary bud being reversed, has the laterality of its new surroundings.

c. Cases similar to the above in their early development but differing later in that the reduplicating bud gained the upper hand and developed into a normal functioning limb of reversed laterality (corresponding to its new surroundings), while the original bud became reduced to a spur or appendage upon the other.

4. Heteropleural dorso-ventral transplantations developed into:

a. Single limbs of reversed laterality somewhat retarded in their development (Rule 2). The great majority of cases.

b. Duplicate limbs. A single case only.

Experiments with superimposed limb buds and with half buds, gave corresponding results, and together with other experiments, show that the mesoderm of the limb bud is an equipotential system, with definite asymmetry (laterality) which is subject to modification in accordance with the fundamental rules stated above. The theoretical questions involved, particularly those relating to adaptation in the individual, are of considerable interest.

11. The effect of removal and regeneration of parts upon metamorphosis in amphibian larvae. CHARLES ZELENY, University of Illinois.

The effect of removal and regeneration was studied by comparing the time of metamorphosis in a set of individuals subjected to operation with the time in a control set. Comparisons were made as follows:

Experiment 1. Rana. The effect on the early development of the hind legs of five successive removals and regenerations of the tail.

Experiment 2. Bufo. The effect of removal of the tail after the beginning of metamorphosis upon the time of completion of the process.

Experiment 3. Bufo. The effect of four successive removals and regenerations of the tail upon the time of metamorphosis.

Experiment 4. Bufo. The effect of two successive removals and regenerations of the tail upon the time of metamorphosis.

Experiment 5. Amblystoma. The effect of three successive removals and regenerations of the tail upon the development of the legs.

Experiment 6. Amblystoma. The effect of removal and regeneration of the tail upon the time of loss of the balancers.

Experiments 7 and 8. Amblystoma. The effect of removal of the right balancer upon the time of loss of the left balancer.

Experiments 9 and 10. Amblystoma. The comparative development of the legs in individuals subjected to the four following degrees of injury: (1) one fore-leg, (2) both fore-legs, (3) one-half of the tail, (4) one-half of the tail plus both fore-legs.

The data from these experiments give no indication that metamorphosis is delayed by removal and regeneration of parts of the body.

12. Life history of Zeugophora scutellaris. B. H. GRAVE, Knox College.

During the summer months the larvae work in the leaves beneath the epidermis, eating out the pulp and causing blackening of the parts affected. A large part of the chlorophyll bearing tissue may be destroyed in this way by the end of summer, thus rendering the leaf ineffective as a starch-making organ. The larva may therefore appropriately be called a leaf miner. Late in the season, at the time the leaves fall it crawls out and enters the ground. After burrowing to a depth of between $1\frac{1}{2}$ and $2\frac{1}{2}$ inches below the surface, it excavates a little spherical cavity in which it coils up for the winter sleep.

About the last of May of the following spring (May 25–June 15) the larvae transform into pupae. The duration of the pupa is about three weeks or possibly a month in cool weather. The first beetles appear by the middle of June. There is reason to believe that they appeared as early as June 10 in the year 1913, which was a rather early spring for that locality.

A number of beetles which were hatched from breeding boxes were kept in captivity and one of them laid eggs ten days after it emerged. It seems likely therefore that under normal conditions the eggs are laid upon the leaves and twigs during the latter part of June and the

first part of July and that the larvae enter the leaves soon after, and begin their destructive work.

The adult beetles, as might be expected, feed upon the leaves of the cottonwood. They swallow the softer parts and discard the fiber.

13. Extirpation of the hypophysis and thyroid glands of Rana pipiens. BENNET M. ALLEN, University of Kansas.

Last spring a series of experiments was performed in the extirpation of the anlage of the anterior lobe of the hypophysis and of the anlage of the thyroid gland. The former experiment was successfully performed upon 430 tadpoles and the latter upon 336.

Removal of the anlage of the anterior lobe of the hypophysis produced a marked contraction of the black pigment cells of the integument apparent at the end of eight days. The silvery cells expanded giving the animals a bright uniform creamy silver color. At this time the hypophysis shows no evident histological differentiation. These operated tadpoles showed marked susceptibility to unfavorable conditions of the water. In the absence of the hypophysis the legs failed to develop, the hind legs appearing as mere buds, up to the maximum stage reached—tadpole of 30 mm. length.

Tadpoles deprived of the hypophysis were carefully studied in stages of 16.5, 21.5, 24 mm. comparisons being made with control tadpoles. The gonads, and thymus glands showed no consistent modification. The thyroid gland in all cases, however, showed a decided diminution in the amount of colloid produced. In tadpoles deprived of the hypophysis the colloid material occurred in far more irregular masses measuring from one-half to two-thirds the diameter of colloid masses in the thyroids of the controls. The general dimensions of the thyroid glands of these animals did not show any appreciable modifications at these stages.

The extirpation of the thyroid anlage caused the tadpoles to halt in their differentiation at a stage in which the hind-limb rudiments were but 4 mm. in length. At the end of November they had shown no further signs of differentiation. Two specimens from which the thyroid had been removed were fed thyroid extracts. In one instance with forty-five days thyroid feeding the hind legs grew to 9.5 mm. length and the fore-limbs grew to 5 mm. length as compared with 4 mm. and 2.5 mm. respectively in the thyroidless controls. They showed much greater differentiation of structure than found in those of the other thyroidless tadpoles. These also showed a remarkable shortening of the intestine in one case to 68 mm. as compared with 190 in the thyroidless tadpoles not fed with thyroid extracts. Studies are being made by students of mine upon the effects of thyroid removal upon the other glands of internal secretion and upon the skeletal system. Seven thyroidless tadpoles of gigantic size are still living, but show no signs of further differentiation.

14. An experimental study of cell division. L. V. Heilbrunn, Department of Anatomy, University of Illinois, College of Medicine.

In the experimental study of a biological process, there are two general modes of procedure. One can attempt to artificially produce or initiate the process, or one can attempt to modify or block the process after it has started. In my study of artificial parthenogenesis, I adopted the former of these methods for studying cell-division. I attempted to analyze the effect produced by the various agents which cause the unsegmented egg to divide mitotically. More recently I have adopted the other method of attack, and I have studied the effect of various agents, which, without injuring the egg, prevent cell-division. Such a suppression of normal activity is of course an example of anesthetic action, and these experiments have incidentally furnished me with considerable data concerning the actual effect of various anesthetics upon the cell.

In a recent contribution it was shown that all agents which cause the egg of the sea-urchin to segment, produce a gelatinization in the cytoplasm. The details of this gelatinization process, as it occurs normally, have now been studied in the same egg. At frequent short intervals after fertilization, the viscosity of the egg cytoplasm was determined by the centrifuge method. After fertilization the cytoplasmic viscosity rises gradually until it reaches a maximum after about twenty to twenty-five minutes.[1] It is precisely at this time that the mitotic spindle first makes its appearance. The appearance of the spindle is followed by a gradual decrease in viscosity, the egg cytoplasm returns to its original fluid state. These viscosity differences are very marked and are easily measured. Similar series of viscosity changes during mitosis can also be demonstrated for the second cleavage. These facts in themselves lend support to the view that the spindle is coagulated out of the cytoplasm.

No doubt the gelatinization is confined to certain chemical constituents of the cytoplasm. On the other hand, it apparently extends throughout the cell and it is attached peripherally to the enclosing membrane, the so-called hyaline layer of the egg. Hence when the gelatinized egg is centrifuged, frequently parts of the egg surface are pulled in, and the shape of the egg commonly undergoes considerable distortion. This attachment to the enclosing membrane is retained by the astral rays of the spindle. Oftentimes when an egg which possesses a spindle is viewed from one pole, its surface contour does not appear perfectly smooth, but shows faint indentations at various points. These points probably represent the points of attachment of the astral rays. The inward pull exerted on the egg surface as a result of gelatinization, no doubt affords the best explanation of the decrease in cell volume which follows fertilization. This is borne out by the fact that in the Cumingia egg, decrease in volume does not immediately follow fertilization. In this egg both gelatinization and shrinkage only occur after a certain time interval has elapsed.

[1] Of course this time varies greatly with the temperature.

If the normal gelatinization of the cytoplasm is prevented, then the spindle never forms, the egg remains quiescent and does not divide. Even after gelatinization has begun, it may be reversed. Ether, chloroform, acetone, paraldehyde, propyl alcohol, isoamyl alcohol, ethyl butyrate, ethyl acetate, ethyl nitrate, acetonitrile, nitromethane, chloral hydrate, phenyl and ethyl urethanes, all prevent or reverse cytoplasmic gelatinization. In the study of the action of these anesthetics, the experimental procedure was usually as follows: soon after fertilization, the eggs were placed in a graded series of concentrations of the anesthetics. Then the viscosity of the various sets of eggs was determined. If the series of concentrations was well chosen, it was found that the highest concentrations produced coagulation, the lowest concentrations no effect, and the intermediate concentrations a liquefaction or reversal of gelatinization. As my studies progressed, I was soon able to predict the fate of the eggs. In the lower concentrations with no marked effect on the egg viscosity, the eggs would go on to divide, in the intermediate concentrations which produced liquefaction, development would be interrupted, but removal from the anesthetic (after a few hours), would be followed by a resumption of development. On the other hand, the coagulation produced by the higher concentrations was generally irreversible, although in a few cases the eggs thus coagulated were able to undergo a few cell-divisions on being returned to normal sea-water. The actual effect of the various anesthetics mentioned above, was to dissolve the lipoids of the egg, or at least to increase their degree of dispersion. In concentrations slightly above that best for anesthesia, the lipoids appeared to be completely dissolved, and no longer separated out when the egg was centrifuged. Such a solution of the lipoids was usually followed, after a short time interval, by coagulation of the cytoplasm.

Low temperatures (e.g., $-5°$ to $5°$C.) also prevent or reverse gelatinization. But this effect of cold is not due to the same cause as is the effect of the other anesthetics just mentioned. In fact when eggs are subjected to both cold and ether the effect of the one tends to counteract the effect of the other.

But not all anesthetics prevent gelatinization. Hypertonic solutions of various salts, although they act as anesthetics, produce quite the opposite effect on the cytoplasm. They intensify the normal gelatinization and in this way prevent cell-division. A similar effect is also produced by chloretone. The action of potassium cyanide is especially interesting. In concentrations of potassium cyanide, far above those sufficient to check development, the early stages of mitotic division are not suppressed. The spindle proceeds to form, but with its formation, development stops abruptly.[2] Apparently the cyanide renders irreversible the normal gelatinization process and no liquefaction follows. If eggs are placed into cyanide solutions during the

[2] The fact that the egg can begin its development in these solutions of potassium cyanide is a strong argument against the oxidation theory of artificial parthenogenesis.

anaphase stage of mitosis, after liquefaction has begun, then cell-division is not prevented.

Since the normal process of mitosis involves both gelatinization and liquefaction, it is easy to understand why agents which cause an intensification of either the one process or the other can check the division of the cell.

As to the direct cause of the gelatinization which follows fertilization, there is some evidence that it is due to salts rather than to an acid. Thus when the cytoplasm is diluted by endosmosis, the gelatinization is reversed. Moreover, whereas coagulation of the cytoplasm by hypertonic salt solutions can be reversed by ether, no other type of cytoplasmic coagulation can be so reversed. It is possible that the gelatinization is produced by the abstraction of water from the cytoplasm by the growing pronuclei. This gelatinization is then to a large extent reversed, when owing to the rupture of the nuclear membrane, the nucleus discharges its water back into the cytoplasm.

But these interpretations are more or less hypothetical. They do not stand on the same firm basis of fact as the observations: (1) That all agents which stimulate to cell-division produce gelatinization, and (2) that any agent which prevents or reverses this gelatinization, prevents spindle formation and cell-division. These two facts, taken together with the observed time relations of the gelatinization process, furnish strong evidence that the force which underlies spindle formation is a cytoplasmic gelatinization.

15. Early castration of the vertebrate embryo. FRANKLIN P. REAGAN, Princeton University (Introduced by C. F. W. McClure).

In 1870 Waldeyer advanced the view that the germ-cells of the vertebrate embryo arise in that portion of the coelomic mesothelium which covers the gonad. Since then a number of observers have described transitional stages between these epithelial cells and primitive ova.

Eigenmann ('91) is justly to be considered the leader of an opposing school who believe that the vertebrate germ-cells are of extra-regional origin. In the viviparous fish Micrometrus, he was able to trace the germ-cells probably to the fifth cleavage—certainly to a time prior to the closure of the blastopore, before there were distinct entodermal and ectodermal layers.

Hoffmann ('93) discovered primordial germ-cells in bird embryos which had not yet formed germinal epithelia. His work has been confirmed by a number of observers.

In connection with the work on avian embryos it is important to note that sex-cells could formerly be found only subsequent to the 22-somite stage; earlier than this their whereabouts was a complete mystery. In fact, stages transitional to them were here less evident than in pictures to be found later in the gonad. An interesting observation was that of Danchakoff, who found in the blood stream very large wandering cells of entodermal origin; these were believed to disappear at the age of 23 somites. Their disappearance was as mysterious as

the first appearance of the germ-cells. It required the insight of Swift ('14) to correlate these two facts and establish a morphological continuity of these large cells from the time of their proliferation by the entoderm, to their incorporation into the gonad. Swift found that these cells originate in a crescent-shaped area of entoderm anterior to the body axis of the very early chick embryo; that they enter the mesoderm which later invaded this region; that they enter the blood vessels forming here and are carried by the blood stream many of them to the base of the mesentery from which they migrate into the gonad.

In 1914, Prof. C. F. W. McClure suggested that the work of Swift could be proved or disproved by the early excision of this crescent-shaped area. I have been able to rear a number of embryos so treated to a stage in which it is possible to determine that the gonads are quite devoid of sex-cells. In normal individuals five days old, the mesenteric mesothelium adjacent to the gonad usually contains many large germ-cells which cause it to protrude locally. Also the mesenteric mesenchyme generally contains some of these big cells. The embryos treated as described have no trace of germ-cells in the gonads, and the neighboring mesothelium remains thin and barren of sex-cells. The stroma tissue of such gonads presents a peculiar foliage-like appearance; it is much vacuolated.

My own interest in this problem lies in another direction. It occurred to me that since castration of individuals subsequent to birth or hatching greatly affects the secondary sexual characters, embryonic castration might produce even more profound effects—that some sexual characters usually considered primary might really be secondary. Such a possibility is heightened by the recent work of Lillie on Freemartin. At present I am led to believe with Lillie that the fate of the Wolffian and Müllerian ducts is dependent on the internal secretion of the gonad. I believe further that if the stroma or interstitial cells are responsible for this secretion, they are unable to produce it in the absence of germ-cells in the early ontogeny; that the nature of this secretion is related only indirectly to the factor or factors for sex by way of emanations from the sex-cells themselves; that the only primary sexual character is the constitution of the germ-cells themselves. These points are not yet completely proved.

Attempts are being made to produce hermaphroditism by transplantation of these entodermal crescents. The effects thus produced on the ductless glands are also being investigated. So far, the transplantation of adult gonad-tissue to young embryos has had no effect on the embryonic genital system, though it has always caused hypertrophy of the spleen of the host.

I wish to thank Professors McClure and Conklin for confirming many of my observations on my material.

It was found impracticable here to discuss thoroughly the results of all previous observers.

16. Microdissection studies. The cell aster: a reversible gelation phenomenon. ROBERT CHAMBERS, JR., Cornell University Medical College. (Illustrated with drawing, to be used in projection apparatus.)

1. The centrosphere is an optically hyaline fluid area occupying the center of the aster and increasing steadily in size until the aster reaches full development. 2. The increase in amount of the centrospheric fluid is apparently due to the accumulation of fluid flowing into the centrosphere from all parts of the cytoplasm. 3. The aster rays are the channels along which the centripetal flow occurs. 4. The cytoplasm between the rays is in the gel state giving a certain amount of rigidity to the aster. The gel state is most pronounced centrally and peripherally passes gradually into the sol state beyond the confines of the aster. When the aster reaches the periphery of the cell the entire cell is comparatively rigid. 5. In the maturation figures of the egg nucleus the peripheral aster forms a continuous coagulum with the surface layer of the egg to which the entire figure is thus firmly attached. The confines of the central aster pass insensibly into the surrounding liquid cytoplasm. 6. A periodic reversal of the sol to the gel state and vice versa has been demonstrated in the cell protoplasm during division. The steps taken may be divided into the following series: *a.* When the monaster is fully formed the greater part of the cell is a gel. *b.* As the centrospheric fluid collects on the two poles of the nucleus the cytoplasm reverses to a sol state and the monastral radiations fade out. *c.* The formation of radiations about the centrospheres, one on each pole of the nucleus, produces the diaster and is accompanied by a return to the gel state. *d.* A return to the sol state later takes place in the equator of the cell. *e.* The nuclear spindle now divides followed by a constriction around the middle of the cell which continues until the cell is cut in two. 7. The reversal of the gel to the sol state usually starts in the equator of the cell and spreads to the poles. The reversal of the sol to the gel begin immediately about the centrosphere and spreads in all directions peripherad. 8. There are appreciable differences in the sol state of the cytoplasm in certain regions and at various times. The interior cytoplasm of the unfertilized and fertilized egg before the aster is formed is slightly viscous. The archoplasm in the centrosphere and in the rays also the hyaline area in the vicinity of the forming polar body are very fluid. 9. What is described as the gel state in living protoplasm cannot be considered as an inert solid coagulum. Even to the eye there is always a constant but very gradual change among the granules imbedded in the cytoplasmic gel.

One may conclude that one of the factors concerned in cell-division lies in the peculiar colloidal property of protoplasm, viz., a periodic reversibility in its sol and gel states.

17. Multiple chromosomes of Hesperotettix and Mermiria. C. E. McClung, University of Pennsylvania.

A restudy of the chromosome complexes of Hesperotettix and Mermiria, upon greatly enlarged collections, has made possible the correction of some errors in the earlier account and the discovery of important new facts. Upon the basis of the present undertanding of conditions in the germ cells of the Orthoptera, numerical variations of the chromosomes are found to be a strong support to the individuality hypothesis instead of militating against it.

The multiple chromosome of Mermiria bivittata, at first thought to be a decad, because of certain constrictions and even divisions in metaphase, proves to be a hexad like the one in Hesperotettix, consisting of a tetrad joined to the accessory chromosome. An explanation of its form and behavior became possible upon the discovery of the J-shaped tetrads in Trimerotropis by Carothers. Full collections make the determination of numbers in the different cell generations certain and consistent with the interpretation of the multiple as a hexad. So far, conditions within the species appear to be constant, but others than bivittata may not have multiple chromosomes, e.g., neomexicana and texana. Within the taxonomic group bivittata, as at present constituted, there are certain sub-groups, first distinguished apart by the form of the multiple chromosomes, that appear to be specifically distinct upon careful study of somatic characters.

As in Mermiria, a study of extensive series of specimens of Hesperotettix shows that the universality of multiples in all species, a condition realized in my earlier collections, does not exist. Moreover the constancy of occurrence within the species sometimes is lacking, as in viridis, and this is associated with a tendency to form multiples between certain of the euchromosomes, producing octads, a name given to such structures in an earlier paper ('05) in advance of their realization in experience. The presence or absence of multiples in viridis results in variations of numbers from 9 to 12 in the first spermatocyte and a supernumerary in one individual out of 37 studied raised the upper limit to 13. The number 11 may be constituted in three different ways. Despite the apparent lack of definiteness in organization suggested by the range in numbers, there is abundant evidence that fundamental conditions are not thus disturbed, because if the final mitotic units, the chromatids, are considered the same 46 are present in each first spermatocyte except in the one individual with a supernumerary. All the evidence indicates that the constitution of the individual established on zygosis are maintained, for no variation was found within the individual.

The chromosome conditions of the first spermatocytes so far observed fall within six different classes; (1) Twelve separate chromosomes consisting of eleven tetrads plus the accessory chromosome dyad—a total of forty-six chromatids; (2) eleven separate chromosomes, ten tetrads plus a hexad—again forty-six chromatids; (3) ten separate chromosomes or eight tetrads plus one hexad plus one octad—

forty-six chromatids; (4) nine separate chromosomes or six tetrads plus one hexad plus two octads—forty-six chromatids; (5) again ten separate chromosomes but in this case consisting of seven tetrads, plus two octads plus one accessory chromosome dyad—forty-six chromatids; (6) again eleven separate chromosomes but consisting of nine tetrads, one octad and the accessory chromosome dyad, forty-six chromatids. In the individual with a supernumerary there are eleven separate chromosomes with the other condition similar to class 5 above.

Criteria for resolving the varying numbers of free metaphase chromosomes into identical series of units of lower order are furnished by comparisons of form, size and behavior and by the structural conditions of the elements. The conditions in class 1 are typical for large numbers of the short horned grasshoppers, the earliest modification of which appeared in the first members of the genus Hesperotettix which I studied, representing class 2. Here the easily recognizable accessory chromosome is joined to a first spermatocyte tetrad, producing a hexad which acts as a unit in this mitosis. Because of this mitotic relation the hexad is properly called a chromosome, but it is just as definitely different from the other members of the complex, for the morphologically distinct accessory chromosome exhibits all its structural peculiarities quite as clearly as if it were a free unit, while the associated tetrad passes through its usual history. The principle of chromosome union is thus definitely and unequivocally established. Only in very recent material have the conditions in classes 3, 4, 5 and 6 been encountered. These involve an extension of the principle of chromosome association to combinations between two tetrads in the first spermatocyte and a persistent union of the non-homologous elements involved throughout the cells of the individual. These combinations result from the endwise union of contiguous sized members of the complex. Thus in class 3 the largest two tetrads are so united, while in class 4 the next two in size also form into another octad. In every case the joined tetrads clearly exceed in size the next in order, just as they do in the free condition, and as the gradation in the complex requires. In synopsis and during the first spermatocyte prophase their behavior is not altered by the association. Union may involve one or both ends of the tetrads producing rings or V's. In the latter case first spermatocyte anaphase groups differ accordingly. Such conditions are accounted for upon the assumption of persistent chromosome individuality and chance union of the classes of gametes actually seen to form. Similar combinations between the accessory chromosome and a tetrad in the long horned grasshoppers were reported by me ('02) and more recently between euchromosomes ('15) by Robertson and by Woolsey. The conditions are therefore not abnormal but represent the action of definite forces of chromatin integration. No evidence is at hand to show how such associations arise or to indicate their later dissolution. The facts demonstrate that numbers are reduced by definite and gradual steps of which the chromosomes are the measure. The normal number is not exceeded by the addition of other

normally constituted chromosomes. Supernumerary chromosomes when present, show their aberrant nature by extra-nuclear position, irregular behavior and great variability. Persistent association of non-homologous chromosomes with elimination of intermediate stages would produce a permanent reduction in the number of free chromosomes. It is possible to account for the occurrence of the lesser number in Stenobothrus in this way, but the criteria for this determination, urged by Robertson, are not completely valid since V-shaped chromosomes with achromatic bridges occur in complexes where no reduction in number exists.

18. The spermatogenesis of Culex pipiens L. P. W. Whiting, University of Pennsylvania, (Section F).

In the spermatogonia of Culex pipiens there are three pairs of V-shaped chromosomes, the members of which are usually approximated. Before division the pairs always lie parallel. One of the pairs is smaller than the other two.

In the first spermatocytes three characteristic tetrads appear, any one of which may form either a cross or a ring. The four elements of the tetrads are distinguishable in late prophase and in metaphase. The dyads separate into monads in the anaphase.

Nucleolar elements are found in spermatogonia, in first and second spermatocytes and in spermatids. In spermatogonia they are associated with one of the large pairs; in first spermatocytes, with a large tetrad; and in second spermatocytes, with a large dyad.

19. The segregation and recombination of homologous chromosomes in two genera of Acrididae (Orthoptera). E. Eleanor Carothers, University of Pennsylvania.

The subjects of this report are the chromosome conditions in the male germ cells of certain species of two closely related genera of short-horned grasshoppers.

A microscopical study of these cells has shed light on three points: (1) the manner of segregation of morphologically distinct homologues, (2) the zygotic composition of the species in regard to these dissimilar homologues and (3) a possible cytological basis for separating confused species of the two genera.

1. The chromosomes are constant in number, size and shape in each animal. In size there is the usual double series, one homologue of each pair being derived from each parent. Contrary, however, to anything heretofore reported these homologous chromosomes may differ in shape—one being a straight rod, the other V-shaped. In one species seven of the twelve first spermatocyte chromosomes may be composed of such dissimilar homologues. This peculiarity affords an opportunity to trace the segregation in the gametes of certain chromosomes derived from both parents. It was found that this segregation occurred according to the law of chance.

2. A study of the chromosome complexes of ninety-five individuals, both male and female, showed the zygotic composition of the species to

be such as would result from the random union of these gametes. These facts furnish an extensive physical mechanism for the operation of Mendel's laws of heredity.

3. One of these genera, Circotettix, has eleven chromosomes in the haploid series of all species studied instead of the usual twelve as found in the other genus, Trimerotropis; on this basis the debated species, Circotettix suffusus which has twelve chromosomes, should be changed to Trimerotropis suffusa.

20. Synapsis and chromosome organization in the male germ cells of Chortippus and Trimerotropis. D. H. WENRICH.

In a recent paper[1] the writer showed that pairing of chromosomes in the first spermatocytes of Phrynotettix magnus is by parasynapsis. All the chromosomes of Phrynotettix are of the rod-shaped type. A study has been made of the first spermatocyte chromosomes of Chortippus (Stenobothrus) curtigennis which has three pairs of C-shaped and five pairs of rod-shaped chromosomes, and of Trimerotropis siffusa, which Dr. E. Eleanor Carothers has found to possess not only pairs of rod-shaped and pairs of V-shaped chromosomes but also pairs consisting of one rod-shaped and one V-shaped chromosome. In all cases the mode of synapsis is found to be the same, viz., a side-to-side union. This mode of synapsis makes it impossible to determine whether the first or the second maturation mitosis is the segregating division unless there is a recognizable difference between the conjugants of a pair.

The V-shaped chromosomes of both Chortippus and Trimerotropis may have the point of spindle-fiber attachment indicated by a constriction, or by a small non-chromatic region, or by both. Since Trimerotropis has a larger total number of chromosomes and (usually) a large number of V-shaped chromosomes than Chortippus, the existence of this "weak place" cannot safely be taken as an indication that these chromosomes are compound.

In Chortippus the point of fiber attachment of the V-shaped chromosomes may be further marked by the presence of a small, appendant, plasmosome-like body, which, when present, is constant in this position on the chromosome. Other such bodies are found on two of the rod-shaped chromosomes of Trimerotropis. Their positions are constant for each chromosome. The constancy of position which these bodies exhibit with reference to the chromosome to which they are attached is additional evidence of the constancy of organization possessed by the chromosomes.

21. The chromosome complex in Apithes agitator. W. J. BAUMGARTNER, University of Kansas.

Apithes agitator is a small brown cricket often called the shrub cricket. It lives on various shrubs, especially the coral berry.

[1] Wenrich, D. H. 1916. The spermatogenesis of Phrynotettix magnus with special reference to synapsis and the individuality of the chromosomes. Bull. Mus. Comp. Zool., Harvard College, Vol. 60, pp. 57–133, 10 plates.

The chromosome complex is very instructive as the number is small and the individual chromosomes are quite distinct in size and shape and behavior.

In the spermatogonia the number is thirteen, two small straight rods, and eleven U-shaped rods. The largest of these always lies on the periphery of the group and its end may be swollen or split or bent at a sharp angle. This has no mate and is the accessory. The other ten easily group themselves into five pairs. The largest pair show a tendency to lie in or toward the center of the equatorial plate. They are frequently somewhat straightened, sometimes showing a double-wave-like curve. The other eight chromosomes with the accessory usually lie in a circle forming the periphery of the equatorial plate. All have the free ends extending outward in the typical way. There is an evident tendency for the two of a pair to lie near together. In size these pairs grade down from nearly as large as the largest to about half of its size.

In the spermatocyte the accessory appears as a sausage-shaped rod, and behaves as described in my earlier papers and confirmed by other observers. The small pair are now a longer rod. It frequently shows a constriction and divides precociously. The two dyads may have separated even before the larger tetrads have been drawn into the equatorial plate of the spindle. The other ten chromosomes now form five very definite rings. All of these enter the spindle parallel with the direction of fibers and not in the plane of the plate as most of the rings do in the grasshoppers.

The fiber attachment is terminal in the small chromosomes, and median or nearly so in all the others. In dividing one end sometimes separates before the other so that the tetrad may appear like a printed capital C for a short time. Sometimes the sides of the rings (ends of dyads) are swollen. When such a tetrad is seen from the side it may appear as a cross with a very short cross arm. But in either the cross or C shapes the fundamental shape is a ring.

The seven elements in Apithes are one accessory sausage shape, one small rod and five rings lying in the plane of the spindles fiber. I believe these shapes are constant, i.e., are assumed in every cycle of tetrad formation. I think this fact is a strong evidence of chromosome individuality.

The five large rings may be multiple chromosomes. If each is counted as a double multiple then the original number would be 5 times 4 plus 2 rods plus 1 accessory equals 23. This number is found in some crickets and most grasshoppers, and seems to be kind of a basic number for these families. Several other species of crickets would have this number if these large rings were counted as double multiple chromosomes. But in two species studied this number is not obtained if the rings are so counted. The interpretation of the large rings as multiples can be stated only as a probability.

22. New facts and views concerning the occurrence of a sexual process in the life cycle of a myxosporidian Chloromyxum leydigi. RHODA ERDMANN, Osborn Laboratory, Yale University.

In a myxosporidian life cycle the sexual process is generally believed to be *before* spore formation. After a shorter or longer asexual life in which the formation of a vegetative body with either two or many nuclei is effected spore formation begins. Since 1910 Auerbach and Erdmann ('11) have verified the suggestion of Doflein that the sexual process might not occur at the above mentioned place in the life cycle but as soon as the young animal leaves the spore. Auerbach and Erdmann found young animals (amoeboidkeim) which had left the spore and possess either two or one nuclei. They are the first step in the new life cycle. Erdmann ('11) could further produce these young forms in a culture which had been made on *gall plates.* In my recent work, finished in 1913, which does not appear until 1916 in consequence of the war, I figure those young animals experimentally freed from the spore after fixation and staining.

Besides myself two other authors, Georgevitch ('14) and Davis ('15) assure that at the beginning of spore formation *no sexual process* could be found. It shows that the recent investigators have finally left the old view that the sexual process of myxosporidia occur immediately *before* spore formation. To support this view I can point out that all processes which were thought to be sexual, i.e., the formation of residual (reduction) nuclei and the heteropole division at the first beginning of spore formation, are only connected with the development of the spore membrane. The *glykogen* which I could point out to be present in the vegetative myxosporidian body, is used up during spore formation. The small cells and their nuclei being the product of the above mentioned heteropole division form the membrane of the spore. Also smaller or bigger chromatic lumps (residual nuclei) are extruded by the nuclei of the sporoblast-cells and are used in forming the sporogenous membrane, and the polar bodies. They cannot be thought to be *reduction* nuclei.

Having pointed out what I believe to be the real significance of these processes, it is more in accordance with the facts presented that the sexual process in the life cycle of myxosporidia is to be found in the beginning of the life cycle after the young animal left the spore.

23. Spermatogenesis in the albino rat. EZRA ALLEN, University of Pennsylvania (Section F).

The haploid, or reduced number of the chromosomes is fundamentally nineteen. The spermatogonial number is consistently 37. There is one accessory. This divides in the second spermatocyte division. One chromatoid body in the cytoplasm and one nuclear plasmosome are present. There is no evidence of double reduction. The chromosomes are of different sizes. In the spermatogonia the forms assumed are rods; in the first spermatocytes, rods, crosses, rings, and single and double loops; in the second spermatocytes, they are all rods. The

organization and behavior resemble the orthopteran. The first spermatozoa are ripe when the rat has reached the age of forty days. The most satisfactory method of fixing and preparing the material for study is described in a paper giving the results of his experiments on technique published by the author in the Anatomical Record, vol. 10, p. 565.

24. Multiple complexes in the alimentary tract of Culex pipiens. Caroline M. Holt, University of Pennsylvania (Section F.)

1. During metamorphosis in Culex pipiens, the number of chromosomes in the cells of the larval intestine is considerably increased.

2. Before disintegration of the cells begins, the chromosomes of each larval gut cell pass through a number of longitudinal divisions resulting in three or four multiplications.

3. The number of chromosomes in the multiple complexes is always a multiple of three—oftenest 6, 12, 24, 48; but frequently 9, 18, 36, and even 72 may appear.

4. The triplex divisions of the chromosomes apparently arise through premature splitting of one member of each pair of daughter chromosomes from the original complex of three bivalents or by a precocious division of one of each of the homologous elements of bivalent chromosomes.

5. The size relation between nucleus and cytoplasm is extremely variable.

6. It appears that in the resting stage of those cells of normal size which contain multiple complexes, there must be an accelerated growth of each chromatin thread which splits into normal sized chromosomes in prophase, or else the cytoplasm of such cells must fail to divide and to grow while the chromosomes continue to do both. The former seems to be the probable explanation.

7. There is evidence of a parasynaptic union of sister chromosomes in the resting stage, followed by reseparation through longitudinal splitting in the prophase.

8. These sister chromosomes, the multiples of each member of the original complex, tend to remain together throughout the mitotic changes.

9. The individuality of the chromosomes is maintained until the cell disintegrates.

10. The disintegrated cells appear to be digested by the cells of the newly formed lining of the adult alimentary tract.

All these facts suggest that increased metabolism of the older epithelial cells may be a means of supplying needed food material to the developing cells of the adult gut during the pupal changes. That this great increase in the amount of chromatin in cells which have attained their growth, functioned for a time, and are about to be absorbed, is not accidental, or simply a process of degeneration seems reasonably clear from the uniformity and universality of this increase in the intestine of Culex. Every cell of the larval gut epithelium apparently passes through the whole series of changes above described

before it reaches the stage of disintegration. If this were simply a process of degeneration, it would be hard to account for the tremendous growth in the chromatin material and for the retention of the individuality of the chromosomes to the end. One would expect the processes observed in the disintegration of the cells, to come directly without these elaborate preparatory phenomena. It would seem that we have here not the hit-or-miss phenomena of degenerating cells, but a definite adaptation to provide for the support of the organism during metamorphosis.

25. Sex-linked inheritance of spangling in poultry. GEORGE LEFEVRE, University of Missouri.

Spangling is the term applied by poultry fanciers to the occurrence of a well-defined spot or "spangle" of distinctive color at the tip of the feather. In the breed of Silver Spangled Hamburgs, for example, the feathers are white and each is tipped with a black spangle which is generally proportionate to the shape and size of the feather. The color-pattern is the same in both sexes.

A series of experiments has been carried out for the purpose of determining the mode of inheritance of spangling, as it was thought that so definite and simple a color-pattern would be favorable for genetic analysis. It is the experience of breeders, however, that the spangled patter is not reproduced closely.

The initial crosses were made reciprocally between Silver Spangled Hamburgs and Brown Leghorns, and the material used for the analysis has been obtained from twelve different matings.

The conclusion has been reached that spangling is determined in inheritance by a distinct factor which behaves in a typically sex-linked fashion, the cocks being homozygous and the hens heterozygous, for it in Silver Spangled Hamburgs. When spangling is introduced through the male, both sexes in the F_1 generation show spangles, while the reciprocal cross gives only spangled males, the females being non-spangled and incapable of transmitting the pattern.

It has been further shown that the expression of spangling may be greatly modified, or even entirely obscured, by the action of other factors, especially factors for black pigmentation, which, however, segregate independently of the factor for spangling.

The disturbing factors may affect the entire body or only some restricted region, as, for example, the feathers of the tail. Black pigment, moreover, may be present in the feathers in other parts than at the tip, and in varying degrees may obscure the definiteness of the spangles. In fact, in certain individuals the condition is reached in which black is developed to such an extent as to completely cover the body, even in cases in which the bird carries the spangling factor, as may be proven by appropriate breeding tests.

In the light of the above facts, it would seem probable that multiple factors for black, introduced by the Brown Leghorns, are present

and that these factors may have a cumulative effect, with the result that pigmentation is developed to varying degrees of extension.

The independence of the spangling factor is shown by the fact that, after segregation and recombination of the several factors concerned, some individuals are extracted in which all disturbing factors are absent and the spangled pattern is exhibited in its original purity. A number of such birds have been obtained from different matings, and these now breed as true to spangling as do the Silver Spangled Hamburgs themselves.

26. Two classes of factors for color patterns in Paratettix. ROBERT K. NABOURS, Kansas Agricultural College.

Fourteen factors for patterns, each allelomorphic to the other, have been used in Paratettix breeding experiments. In this class two factors for any one suffice to make the whole pattern, and two for different ones produce a hybrid pattern, intermediate in fact, though the one may be more apparent (epistatic) and the other less apparent (hypostatic). These are well established as multiple allelomorphs. *Each of these factors is invariably allelomorphic to a multiple allelomorph, never to an absence.*

Another class of factors, existing without exception in connection with and in addition to the multiple allelomorphs, has been discovered. The one factor most studied produces a well marked melanism in addition to any of the other patterns or their hybrids. It is also possible to distinguish in the patterns between the presence of a single and double dose of the factor. *This factor is allelomorphic only to its absence and never to anything.*

The multiple allelomorphs among themselves produce the typical 1 : 2 : 1 (in some cases apparently 1 : 3) ratios. When the non allelomorphic factor is present the typical 9 : 3 : 3 : 3 : 1 (actually 1 : 1 : 1 : 1 : 2 : 2 : 2 : 2 : 4) ratios are secured. The clear definition of the patterns and the ratios indicate the presence of only one pair of allelomorphic (allelomorphic each to the other) factors, and one unpaired (allelomorphic only to its absence) factor in the production of the 9 : 3 : 3 : 3 : 1 ratios. This conception applies perfectly to similar phenomena in other forms. Considering one example in peas: it appears that the factors for roundness and wrinkledness are each allelomorphic to the other, while the factor for yellow is unpaired and allelomorphic only to its absence and never to anything. It is completely misleading to assume that the factor for yellow forms an allelomorphic pair with green. Another case is that of combs of fowls: pea and single appear to form an allelomorphic pair, and there is another factor, behaving as the unpaired one for the melanism in Paratettix and yellowness in peas, which, when present, modifies single to make rose (the one rose being single heterozygous for this factor, and the other kind of rose being single homozygous for it), and which modifies pea and the hybrid of pea and single to make the four kinds of walnut. It is misleading to consider rose a character; it is a modified single.

Pea with heterozygous and homogyzous doses, respectively, of the modifying factor makes two kinds of walnut, while the hybrid (pea and single) with heterozygous and homozygous doses, respectively, of the modifier makes the other two kinds of walnut.

The data and fuller discussion are in press.

27. The relation of yellow coat color to black-eyed white spotting of mice, in heredity. C. C. LITTLE, Harvard Medical School.

It has been known for some time that mice homozygous for the factor producing yellow coat color have never been observed. Castle and Little ('10) showed that the ratio of yellow to non-yellow young when two yellow mice are crossed together is approximately 2 : 1. This is explicable on the ground that the homozygous yellow individuals are formed but fail to develop.

A similar condition has been found to exist in the case of the factor producing black-eyed white spotting in mice. When two black-eyed whites are crossed together they produce approximately two black-eyed whites to one ordinary piebald mouse. Black-eyed whites are always heterozygous and carry the ordinary type of spotting as an hypostatic character.

A series of experiments have been carried on to determine whether or not the lethal action of the yellow factor and the black-eyed white factors is identical. It has been shown that they are entirely distinct in nature. This is proved by the breeding tests of the classes of young produced, by the size of litters, and by the ratio of yellow to non-yellow animals in F1. In the course of the experiments it became evident that in both "black-eyed white" and piebald animals which are "yellows" the amount of dorsal pigmentation is from 5 to 30 per cent greater than "non-yellows" of the same two color types. As yet, there is no evidence as to whether this is due to interaction of the yellow and black-eyed white factors or whether it is due to some distinct genetic factor linked with yellow color.

28. Mutation in Didinium nasutum. S. O. MAST, Johns Hopkins University.

In a series of experiments on the effect of conjugation and encystment in Didinium extending from April, 1910, to May, 1914, there suddenly appeared a marked difference in the rate of fission in the progeny of a single individual. This difference appeared in the latter part of July, 1912, in a line which had at that time produced 721 generations without conjugation and 197 generations without encystment. The difference was still evident, apparently without diminution, when the experiment was closed after having continued 315 days. There was great variation in the rate of fission from day to day depending largely upon changes in temperature, but the difference in the rate of fission in two groups of lines remained fairly constant throughout.

During the 315 days over which the experiment extended the more rapid lines produced a total average of 838 generations and the less

rapid lines a total average of 634 generations. The death-rate in the two groups was nearly the same, as was also the tendency to encyst and to conjugate.

29. The occurrence of mutations in skunks of the species, Mephitis putida and M. hudsonica. J. A. DETLEFSEN. Coll. of Agr., Univ. of Ill.

Eleven mutant skunks of the species Mephitis putida and three mutants of the species M. hudsonica have been found. In the former species we have, or had, in our possession four living individuals and received hair samples of two other mutants. In the latter species we have one living mutant and hair-samples of two other mutants. The mutants are as follows:

Mephitis putida

Female: White hair on body; few brown hairs on face; eyes black. Successfully bred to normal male, producing three normal offspring.

Female: White hair; eyes pink except a narrow ring of pigment on the outer margin of the iris. Successfully bred to normal male, producing seven normal offspring.

Two female albinos with pink eyes (in our possession).

Male albino, an albino of unknown sex and two solid blacks of unknown sex have been reported to us. Male and two female brown skunks (hair samples received.)

Mephitis hudsonica

Albino male: White hair and pink eyes (in our possession).

Male and female brown skunks (hair samples received).

30. The influence of parental alcoholism on the learning capacity of the offspring. E. C. MACDOWELL, Carnegie Institution of Washington.

Rats from alcoholized parents have been compared with their double first cousins from normal parents. No structural differences between the rats of normal and alcoholic parentage have been found. The number of rats in a litter averages slightly lower in the matings of alcoholics. Three methods have been employed in rating the capacity for learning:

1. Puzzle box. To enter, the rat must release the door by going behind the box and breaking an electric current; results based primarily on the time of operation.

2. Yerkes multiple-choice apparatus. The problem is to choose the correct door, from a variable series of opened doors, according to its relationship to the other opened doors; results based on the numbers of correct first choices, and the numbers of wrong choices.

3. Watson circular maze. Five choices of going to the right or left are offered; the correct path is followed on choosing right and left turns alternately, results based on time, and camera lucida tracings of the distances run in every trial.

Three groups of litters have been studied. These include 64 rats from normal parents, 54 from alcoholic parents. All the rats in each group are double first cousins.

Group 1. Tested with the puzzle box, the rats of alcoholic parentage, are faster; tested with the multiple-choice apparatus, two litters in this group show the normals to be the better choosers.

Group 2. Tested with the puzzle box the rats of alcoholic extraction are faster.

Group 3. Tested with the puzzle box, the normal rats are faster than those of alcoholic parentage; tested with the multiple-choice apparatus the rats from normal parents are again more successful; two litters in this group tested with the maze, show that the rats from alcoholic parents are faster and cover less ground in learning.

31. Linkage in the sex-chromosome of a new species of Drosophila. (Introduced by C. B. Davenport.) CHAS. W. METZ, Carnegie Institution of Washington.

In an undescribed species of Drosophila several sex-linked mutants (as well as several non-sex-linked ones) have been obtained, and have been studied for linkage. The factors for these sex-linked characters fall into a linear series when arranged according to their linkage relations, in much the same manner as factors have been shown to do in Drosophila ampelophila. By means of this series it is possible to make a comparison between corresponding linkage groups, and perhaps even between corresponding individual factors, in two related species.

32. An examination of the so-called process of contamination of genes. THOMAS HUNT MORGAN, Columbia University.

A sex-linked mutant factor in Drosophila called Notch produces two effects, a notch in the wing (dominant) and a lethal effect (recessive) so that no notch males ever appear. In the heterozygous females the notch varies between a well-marked serration at the end of the wings to an occasional fly with wings having the normal margin. Through several generations females were selected that had the least amount of notching and then through several generations more females were selected that had notch in only one wing. Such females had both the normal factor and the notch factor, but the notch character was so slightly developed somatically that it showed only on one wing. To those who believe that a somatic character can be used as a measure of the 'potency' of the factor affecting the character, this one-sided development would appear to fulfill the conditions nearest to 'genic weakness.' Finally, the character was carried further in stock that had one other recognizable factor close to Notch on each side, so that the character could be followed by its linkage even after it had been selected into invisibility, i.e., normal winged flies that carried the factor could be selected and the stock bred from them. Suitable tests will be pointed out by means of which one can find out

whether selection has accomplished its result by piling up modifying factors, or by the isolation or allelomorphic mutations, or perchance by causing 'allelomorphic fluctuations' occasioned by the 'contamination' of the genes.

33. An analysis of the effect of selection on bristle number in a mutant race of Drosophila. A. H. STURTEVANT, Columbia University.

A mutant race of Drosophila, known as 'Dichaete,' was found to be variable in the number of bristles present on the thorax. A selection experiment has been carried out on this character, involving over 25,000 flies and extending through fourteen generations. Both plus and minus races have been obtained. These races have been tested, by means of the linkage method, to see if the differences between them were due to modifying factors or to changes in the Dichaete gene itself.

34. The elimination of males in alternate generations of sex-controlled lines. CALVIN W. BRIDGES, Columbia University. (Introduced by T. H. Morgan.)

There have been demonstrated in Drosophila sex-linked genes, which kill all males receiving such genes. Recently a sex-linked lethal (lethal 10) has been found which allows an occasional male with the lethal gene to come through as a pale-colored dwarf. These rare dwarfs are fertile and transmit to all their daughters the lethal gene and consequently the power to produce only half as many sons as daughters. By mating a lethal 10 dwarf to a female carrying another lethal (lethal 12) whose locus in the X chromosome is exceedingly close to the locus of lethal 10, females are obtained that are incapable of producing any sons except the rare dwarfs, although producing 200 or 300 daughters.

35. Coincidence of crossing over and the chromosome theory of linkage. ALEXANDER WEINSTEIN, Columbia University. (Introduced by T. H. Morgan.)

It has been found in Drosophila that a crossing over in one region of a chromosome tends to prevent crossing over in a neighboring region. This has been termed interference. The likelihood that one crossing over will interfere with another decreases with increase of distance between them. The present evidence indicates that if this distance becomes sufficiently great, interference disappears entirely; and as the distance increases still further, interference reappears. These results have a definite bearing on the twisting of the chromosomes. They are in accord with the chromosome theory of linkage, and any other theory must be able to explain them.

36. Determinate and indeterminate laying cycles in birds. L. J. COLE, University of Wisconsin.

There appear to be two distinct types of laying cycles in birds, one in which the number of eggs which will be laid in the clutch is definitely

determined when laying begins and the other in which the number of eggs that will be laid depends upon stimuli received after laying has begun. In other words the stimulus for cessation of laying and inception of brooding has already been received and the reaction predetermined in the first case, while in the second the stimulus is received later and is followed by cessation of liberation of ova from the ovary, though laying continues for a time afterward until the ova already discharged have received albumen and shells and have been expelled. The most important stimulus for the onset of broodiness, and the consequent cessation of laying, in the second class of cases is probably a physiological reaction of the female to a number of eggs in the nest. As a consequence, if the eggs are removed as laid the stimulus does not occur and laying continues beyond the regular clutch to an indefinite number.

Among domesticated birds the pigeon may be taken as an example of the determinate type and the common fowl of the indeterminate. Among wild birds experiments have been carried on with the English sparrow and the house wren, which also appear to represent the two types respectively.

37. A strain of sex intergrades. ARTHUR M. BANTA, Carnegie Institution of Washington.

From an individual brought into the laboratory in August, 1912, several separate strains of Simocephalus vetulus have been propagated for more than 150 generations. Only parthenogenetic reproduction can have occurred for—in the first place individuals are isolated when released from the mother's brood pouch—long before the sexual products are matured; in the second place for 130 generations no males or fertilizable eggs appeared in this stock; and in the third place the individual culture bottles are not retained long enough for a fertilized egg to develop if fertilized eggs were produced. Hence there are three reasons, any one of which is sufficient in itself, for stating positively that sexual reproduction cannot have occurred in this strain for 130 generations. There can, then, be no question of a recent hybridization within this stock.

In addition to the character of the gonads (primary sex characters) which is readily determined by examination of the living animal with the microscope, eight definite morphological secondary sex characters are recognized.

In October, 1915, in one of the six strains of this line there suddenly appeared sex forms in a remarkable array and this array of peculiar sex forms has persisted for more than 25 generations. None of the other five strains coming from the original mother more than 150 generations, and more than four years ago, has to date produced males. The strain producing the sex forms is not inferior to its sister strains in vigor or productivity.

The sex array in the sex intergrade strain consists of normal females, female intergrades having one to eight male secondary sex characters,

hermaphroditic intergrades with various combinations of male and female primary and secondary sex characters, male intergrades with one or more female secondary sex characters, and normal males.

Roughly the various sex forms fall into the classes indicated but really no precise and definite classification is feasible. Almost every possible combination of primary and secondary male and female secondary sex characters occurs. There is nearly every gradation between a normal female and a normal male. A single individual, even a single gonad, may produce eggs and sperm at the same time or sperm at one time and eggs at another.

There is a distinct, though not very precise, relation between the secondary and the primary sex characters. Usually an individual with most of its secondary sex characters male will have testes, and conversely an individual with most of its characters female will have ovaries. However many female intergrades have five or six male characters. Some have all their secondary sex characters those of a male.

Male intergrades usually produce few sperm or have incompletely developed reproductive systems. Female intergrades with all the secondary characters male are sterile. Those with as many as six male characters as usually sterile, while those with four or five male secondary characters are frequently sterile or show a much reduced productivity. Sterile individuals begin to develop eggs but they either disintegrate in the ovary or die in the brood pouch. Females with few male characters are usually normal in vigor and productivity. The proportion of the various sex forms produced by the different mothers varies greatly but in general those mothers which are themselves intergrades produce a larger percentage of males and intergrades than normal females in this strain.

Sex here is obviously a purely relative thing. There exists a graded series from normal females, to female intergrades with one to several of their secondary characters those of a male, to hermaphroditic intergrades with various combinations of primary and secondary male and female characters, to male intergrades with, in some cases several, in other cases a single female secondary sex character, to normal males. Maleness and femaleness are not definite and fixed mutually exclusive states but are quantitative and purely relative things.

38. Effect on fertility of crossing closely and distantly related stocks of Drosophila ampelophila. Roscoe R. Hyde, Indiana State Normal School.

The fertility of Drosophila ampelophila is probably very high in nature as shown by the fact that about twenty wild stocks taken from widely separated regions have given a fertility of from 80 to 100 per cent when tested in the laboratory. These stocks when inbred have shown without exception a decline in fertility. The per cent of eggs that give rise to mature flies has dropped in some stocks to as low as 25. When these stocks are crossed a marked rise in fertility above that of the parent stocks used for control occurs both in the cross and its reciprocal.

This result stands out in marked contrast to that obtained when a stock is divided into strains and separately inbred. In this case the strains may loose different degrees of fertility. When the stocks are recombined there is no rise in fertility beyond the parent stock with the highest fertility. The control strain with the highest fertility brings the fertility of the lower strain up to its level but not beyond.

39. Are the polyradiate cestodes mutations? FRANKLIN D. BARKER, University of Nebraska.

It is not surprising to find terata or "freaks" commonly among such erratic and degenerate animals as the cestodes or tapeworms. Of these abnormal forms the most rare and in many ways the most unique are the polyradiate or "double" cestodes having the appearance of two worms variously fused giving rise to two, three or more "wings" or sides. These are known as dihedral, trihedral and polyhedral cestodes. Such terata have been found among the cestodes of man, horse, dog and cat.

One of the most interesting aspects of these abnormalities, as with all terata, is their origin. A number of theories have been advanced by various parasitologists to account for their origination such as, the partial fusion of two normal adult cestodes (Bremser); the primative malformation of the scolex with subsequent partial fusion of two worms (Vaillant); the fusion of two normal embryos which give rise to a double adult (Leuckart); several helminthologists have described these anomalies as distinct varieties of the normal species while others have even gone so far as to consider them as new and distinct species (Kuckenmeister +).

A similar anomaly has been reported among six species of cysticerci or larval cestodes and an abnormal number, more than six hooks, is frequently found in the onchosphere or first larval stage of practically all species of cestodes.

Foster ('15) has recently reported the results of experimentally feeding to a rabbit, two gravid segments of a triradiate Taenia pisiformis "shipped in a solution of formaline of unknown strength, and kept in a 2 per cent solution of formalin for one week." Seven cysticerci were found fully grown and entirely normal.

We published in Science, 1910, the finding of specimens of trihedral Taenia serrata = (T. pisiformis) and Taenia serialis. Unfortunately the specimens had been killed and fixed before we discovered their trihedral character.

On July 29 of this year we had the good fortune to find a perfect mature trihedral Taenia serrata in the intestine of a collie dog picked up on the streets of Lincoln, Nebraska. The last two gravid proglottids of the living worm were teased in physiological salt solution and 3 cc. of this solution containing the freed eggs was fed to each of three half-grown rabbits born and raised in our laboratory pens. Three rabbits from the same litter were kept as checks. August 2 one infected rabbit died from unknown cause. No trace of cysticerci was found.

August 13, one of the uninfected rabbits died from unknown cause. No cysticerci were found. October 16 one of the infected rabbits was killed and 31 cysticerci were found attached to the omentum, liver and posterior end of the colon. Twenty-six of the cysticerci had well developed scolices and 5 were immature. Sixteen cysticerci were removed from their protective cysts and placed in 200 cc. of digestive fluid made up of distilled water, 0.2 per cent pancreatin, 0.6 per cent NaCl, and 5 per cent saturated solution sodium carbonate and kept at blood temperature, 37°C. in an incubator for ninety minutes. The 11 mature cysticerci completely evaginated their scolices in from thirty to ninety minutes. All scolices were perfectly normal with respect to number of suckers and hooks. October 17 16 cysts were fed to a 6 months' old dog. November 18, dog was killed and 3 hookworms (Uncinaria trigonocephala) and 1 Taenia serrata were found firmly attached to the wall of the lower end of the small intestine. The cestode was perfectly normal though immature, measuring in a relaxed condition 5.5 cm. The last two proglottids were asymmetrical indicating their original nature. The small number of worms found indicates a lack of vitality of the cysticerci, while the absence of other parasites commonly found even in puppies points to a natural immunity or an unfavorable condition of the intestine. November 27 the third infected rabbit was killed. Six cysts were found, 4 attached to the omentum and 2 to the colon. Five cysticerci were mature, and all were perfectly normal. November 28 the two remaining uninfected rabbits were killed but no cysts were found. The results of these feeding experiments prove conclusively that the eggs of polyradiate cestodes develop into normal worms and do not give rise to polyradiate forms and therefore are not mutants, distinct varieties or species, but are terata or abnormalities which probably arise, as we have previously suggested, from the occasional partial and incomplete separation of early blastomeres of embryos of normal cestodes.

40. A revised working-hypothesis of mimicry. W. H. LONGLEY, Goucher College.

There is grave reason to doubt the existence of animals whose conspicuousness under normal conditions has been exaggerated by natural selection. It seems desirable, therefore, to attempt to discover what explanation of mimetic resemblance is possible upon the assumption that the colors of insects are correlated with their habits, tend to reproduce characteristic tones of their surroundings, and to obliterate their possessors under the conditions in which they live.

It is to be noted that this supposition is perfectly consistent with the many verifiable facts that have been discovered by special students of mimicry. Upon the basis it provides, it is to be anticipated that mimic and model should commonly be found living under the same conditions; that certain groups of insects should show the same local color varieties; that diversity of coloration should appear in one group of butterflies or moths and ally them in outward appearance with dif-

ferent genera; and that insects with every variety of larval experience, as adults should possess the same type of coloration, and superficial resemblance which they attain in the most diverse fashion. The same may apparently be stated of all other admissible evidence, which has been assumed to prove the validity of the Batesian and Müllerian hypotheses.

Upon the other hand recognizable deficiencies in current explanations of mimicry, and criticisms levelled against them, seem adequately met by the revised hypothesis. There is no longer any difficulty in comprehending how even the initial stages in mimetic resemblance could minister to the advantage of their possessor. One's credulity is no longer overtaxed by the demand to believe that when the patterns of scores of species of one locality present a single combination of colors, they reveal the effect of natural selection directed toward the production of resemblance. One is able to escape the inquisitor who wishes to know how creatures, which were capable of being deceived by the first vague resemblance between two species, have been able by selection to push the agreement between the two to the point of apparent identity, and even the occurrence of the 'mimic' beyond the range of its 'model' is capable of rational explanation.

It is therefore suggested, as a working-hypothesis, that mimicry has been initiated and advanced by indiscriminate feeders. These have exerted bionomic pressure, and forced their accustomed prey to assume color combinations which most effectually conceal it in its normal environment. In the evolution of types of coloration appropriate to the surroundings and habits of their possessors members of one genus have occasionally followed different courses, and fortuitous resemblances to various unrelated genera have occurred, capable of deceiving enemies, which exercise discrimination in their choice of food. At this point selection directed to the production of deceptive resemblance has been superimposed upon processes culminating in the development of types of obliterative coloration without changing the general trend of their evolution.

41. Recent studies of nerve conduction in Cassiopea. ALFRED G. MAYER.

Researches conducted at The Tortugas Laboratory of the Carnegie Institution of Washington upon Cassiopea indicative that nerve conduction in this medusa is due to a chemical reaction involving the cations of sodium, calcium, and potassium; magnesium being relatively non essential.

The sodium and calcium cations together appear to combine with some undetermined proteid element to form an ion-proteid. The probably high temperature coefficient of ionization of this ion-proteid may account in some measure for the high temperature coefficient of the rate of nerve conduction, which is 2.5 as great as that of the electrical conductivity of the sea water surrounding the nerve.

The rate of nerve conduction is probably accelerated by an enzyme as stated by E. N. Harvey, 1911.

R. S. Lillie, 1916, American Journal Physiol., vol. 41, p. 133, appears to be mistaken in assuming that the rate of nerve conduction is a function of the electrical conductivity of the solution surrounding the nerve, for the decline in rate of nerve conduction is practically identical whether we dilute sea water with 0.415 molecular $MgCl_2$ or with distilled water. In other words whether we maintain a constant electrical conductivity or reduce it in a ratio nearly commensurate with the dilution. Thus Lillie's "local action" theory appears not to be supported.

My former idea that adsorption of $Na^{\cdot}$, $Ca^{\cdot\cdot}$, and $K^{\cdot}$ played an important rôle in nerve conduction is erroneous. I was misled by the effects due to a slight acidity of the distilled water, and I did not reduce all observations to a constant temperature, which is essential, due to the high temperature coefficient of the reaction.

42. The theory of sex as stated in terms of results of studies on the pigeons. Oscar Riddle, Carnegie Institution.

Studies which have demonstrated the reality of the control or reversal of sex in pigeons (Whitman, and later Riddle) have at the same time indicated the *nature* of the initial difference between germs of prospectively different sex-value. This difference rests upon different *levels of metabolism;* and when the metabolic level of a given germ is shifted from the level characteristic of the germ of one sex, sufficiently toward the level of the other sex, it develops into an organism of the sex which corresponds to the acquired, or later, level.

The *initial* difference characteristic of the two kinds of (sex) germs, tends to persist and characterize the adults of the two sexes.

Sex is based on a quantitative difference; intermediates of the normal extremes have been experimentally produced, and the normal extremes have themselves been experimentally accentuated.

There seems to be no known body of facts in contradiction of this view; though the facts obtained from the pigeons are in direct contradiction of some of the more or less current theories.

43. The adaptive color changes of tropical fishes. W. H. Longley, Goucher College. (Illustrated with lantern.)

The colors of tropical reef-fishes are correlated with their habits. Their color changes may occur almost instantaneously, and in many species even those of unconfined individuals are subject to direct control by the observer. In general, they enable the animals that display them to repeat upon their own bodies the characteristic tones of the various environments in which they move.

Photographs secured with a submarine camera and diving-hood record some of the changes in coloration which Epinephelus striatus and Lachnolaimus maximus commonly exhibit, and indicate their effect in reducing the creatures' conspicuousness. Others show how particular elements in a complex pattern such as that of Abudefduf saxatilis blot out their possessor's contour, when the animal is viewed against an appropriate background.

A great body of evidence indicates that more than minimal conspicuousness may not be ascribed rationally to bright colored fishes as a class, and strikes at the foundation of some of the most widely disseminated hypotheses of animal coloration. Obviously, however, it suggests that the characters in question are useful, and that their development has been largely controlled by natural selection.

44. The histological basis of adaptive shades and colors in the flounder, Paralichthys albiguttus. ALBERT KUNTZ, St. Louis University School of Medicine.

Changes in shade and color in fishes are due primarily to changes in the distribution of the pigment granules in the chromatophores in the superficial layers of the skin and changes in the relationships of the guanophores (cells containing guanin crystals) with these chromatic organs.

The skin of Paralichthys albiguttus contains chromatophores of two distinct types, viz., melanophores and xanthophores. The former contain melanin granules which vary in color from dark brown to black, the latter contain xanthine granules which vary in color from yellow to orange.

Under experimental conditions pigment granules can be observed advancing toward the periphery and in turn retreating toward the center of the chromatophores along more or less definite radial lines. Ameboid movements of the chromatophores can not be observed in adult specimens. Neither could evidence be obtained from preparations of the skin which indicates that the chromatophores contract and expand in an ameboid manner. Changes in the distribution of the pigment in the chromatophores are accomplished by movements of the pigment granules within the cells and do not involve essential changes in the form of these organs.

A comparative study of living material and preparations of the skin of specimens of Paralichthys albiguttus adapted to backgrounds of various shades indicates that shade depends primarily upon the degree of distribution of the melanin pigment in the melanophores and the spacial relationships of the guanophores with these bodies in the superficial layers of the skin. The xanthophores probably play no important part in the determination of shade.

The most obvious response to a change in the color of the background is a change in the distribution of the xanthine granules in the xanthophores. Shades of yellow and orange depend primarily upon the degree of distribution of the xanthine granules in the xanthophores containing yellow and orange pigment respectively. In general the particular quality of the color assumed by the fish depends upon a complex group of factors which do not lend themselves readily to a detailed analysis. Some of the colors assumed may be duplicate by mixing pigments of the colors represented in the pigments contained in the chromatophores. These colors depend primarily upon the degree of distribution of the pigment granules in the melanophores

and xanthophores respectively. Colors which can not be duplicated in this manner, doubtless, depend upon the relative degree of distribution of the pigment granules in the melanophores and xanthophores plus the optical effects due to the diffraction of light by the guanin crystals in the guanophores. The optical effects produced by the guanin crystals are probably modified by the particular spacial relationships of the guanophores with the chromatic organs.

Obviously, certain colors are simulated by the fish more perfectly than others. Among the colors used in the present investigation yellow and green were simulated more perfectly than dark red and dark blue. None of the specimens placed on a dark red background showed any color which approximated the color of the background more closely than the orange pigment in the xanthophores. In view of these facts the conclusion that all colors can be reproduced in the skin of the flounder is unwarranted.

Adaptation to a yellow background involves a moderate degree of concentration of the pigment in the melanophores and a marked degree of distribution of the pigment in the xanthophores in the superficial layers of the skin.

Adaptation to a green background involves a marked degree of distribution of the pigment in the melanophores and a moderate degree of distribution of the pigment in the xanthophores in the superficial layers of the skin. The resultant yellowish green color probably depends upon the ratio of the distribution of the xanthine to the distribution of the melanin pigment plus the optical effects due to the diffraction of light by the guanin crystals in the guanophores.

Adaptation to a dark red background involves almost maximum distribution of the pigment in the melanophores and the orange colored xanthophores and a marked degree of concentration of the pigment in the yellow xanthophores in the superficial layers of the skin. The resultant reddish brown color is due largely to the wide distribution of orange pigment, the effect of which is probably modified by the blending of orange and black and the optical effects produced by the guanophores.

Adaptation to a dark blue background involves almost maximum distribution of the pigment in the melanophores and almost maximum concentration of the pigment in the xanthophores in the superficial layers of the skin. Many of the guanophores also become arranged with reference to the melanophores and closely associated with them. Doubtless, the resultant greenish blue color depends largely upon the optical effects produced by the guanophores which are closely associated with the melanophores. The dark shade is due to the wide distribution of the melanin pigment.

45. Further data on the relation between the gonads and the soma of some domestic birds. H. D. GOODALE, Massachusetts Agricultural Experiment Station.

The results of published data on the ablation of the testes and ovary of domestic birds together with unpublished data on the transplanta-

tion of the ovary into castrated males has made it clear that different parts of the soma react in different ways to the secretion of the gonads. Each character appears to be more or less independent of every other character just as they are more or less independent in heredity. The various characters fall into several groups. We may recognize, first, characters (including some of the secondary sexual characters) that are independent of either ovary or testis. Such characters are, size in the female, voice and some phases of behavior, and mandible color in ducts. Second, characters affected by the testis, such as comb and wattles, fat deposition, size in the male, and some instincts and summer plumage in ducts. Third, characters that are affected by the ovary, such as plumage form and color and some phases of behavior.

No sharp line can be drawn between the better known secondary sexual characters and those commonly considered ordinary somatic characters, for the reaction of a character to the secretion of either gonad varies not only according to the character itself but also according to the original sex of the individual. Thus, the size of the primary coverts in relation to the primaries is approximately the same in each sex but after removal of the testes they become disproportionately large, though not after removal of the ovary. The spurs always develop in the female after removal of the ovary, but they also develop in the capon and in feminized cockerels, i.e., in the presence of the ovary in the soma of the male. Females from which the ovary has been removed are neutral in sexual behavior but one of the most astonishing things about castrated males with implanted ovaries is that they exhibit only the sexual behavior of the male. The comb and wattles do not develop in the male after castration, i.e., are infantile; in the castrated male with engrafted ovary they are fully feminized; in the ovariotomized female they may be either female-like or male-like. The capon exhibits two characters that are female-like, viz., the amount of fat deposited and the brooding instinct. On the other hand, two masculine characters are intensified by the removal of the testes, viz., body size and plumage length. The ovariotomized female is approximately the size, however, as her normal sisters, while the castrated male with engrafted ovary has the size of the male. The plumage shape seems to be completely controlled by the ovary, since wherever that is present the shape of the feather is like those found on intact females. The color is less completely controlled by the ovary for while females from which the ovary has been removed develop the colors of the male, only a portion of those males with engrafted ovaries have developed the female's color, though they do not develop all the colors of the male, particularly the brilliant colors. In ducks there is a greenish pigment of the mandible that disappears from the mandible of the castrated female, but since the mandible color of the male with engrafted ovaries is unaltered, it appears that castration induces a previously non-existant difference between the sexes. Finally, there are characters that behave one way in some individuals and in another way in others. This is particularly noticeable in the plumage of the ovariotomized ducks, which in particular

regions may vary from a purely masculine condition to a purely female condition or to a condition sui generis.

If the entire series of altered individuals is examined, it is apparent that it may be looked upon as a series of sex intergrades. That is, characters that are normally found in one sex may be experimentally transferred to the opposite sex while individuals composed of mixtures of such characters may be obtained.

46. The sensory potentialities of the nudibranch 'rhinophore.'[1] LESLIE B. AREY, Northwestern University Medical School.

Nudibranch mollusca possess a pair of short, robust dorsal tentacles which are commonly perfoliate or ringed and which may or may not be retractile. These important looking tentacles have long been designated 'rhinophores,' and it is tacitly assumed that they are indeed specialized olfactory organs. The presence in certain species of long, more or less dorsally placed tentacles, in addition to the oral tentacles and rhinophores, heightens the suspicion that the latter may perhaps serve some particular sensory function.

The sole experimental evidence upon which the assignment to the rhinophores of an olfactory activity rests seems to be found in the observations of Graber in 1877 (Biol. Centralbl., Bd. 8, No. 24, pp. 743–754). Graber brought oil of rose near the head of Chromodoris elegans and observed the withdrawal of the rhinophores to be quicker and more vigorous than that of the oral tentacles. He emphatically states, however, that the post-branchial region is the most sensitive part of the body.

It would thus appear that the convenient term 'rhinophore' is of dubious propriety. For this reason Bermudian nudibranchs were subjected to experimentation designed to test their sensory potentialities. Unless otherwise stated the following account applies to Chromodoris zebra Heilprin.

Tactile stimulation. When a rhinophore is touched lightly with a glass rod it is jerked back precipitately within its protecting collar. The sensitivity of the rhinophore to gentle stimulation is astonishing and the explosive type of response is, within wide limits, independent of the strength of the stimulus. Fatigue comes on but slowly, responses of somewhat diminished intensity being readily obtained after fifty successive stimulations at ten-second intervals.

The oral tentacles, gill plumes and the general body-surface all respond to tactile stimulation. It is unsatisfactory to list the several regions of the body in the order of their sensitivity, for the types of responses are not all comparable. It appears, however, that the so-called rhinophore is the most sensitive part of the body and considerably more so than the oral tentacles.

Thermal stimulation. The head region and especially the oral tentacles react distinctly to water at 40°–50°C. applied with a pipet.

[1] Contributions from the Bermuda Biological Station for Research, No. 52.

The rhinophores, on the contrary, give faint and rather doubtful responses except to temperatures as high as 50°C.

Chemical stimulation. Equal volumes of various chemical solutions were applied from a constant distance with a pipet. Solutions of 1 M of maltose, or sucrose, or M/2 of lactose were without effect upon all parts of the body, although 3 M glycerine did evoke general responses. Several alkaloids had very weak effects or none at all. Alcohols and organic acids in concentrations of M/10 called forth strong general responses. The chlorides of the alkali metals Na, K, NH_4 and Li likewise stimulated the body in general, the rhinophores and oral tentacles, however, showing the greatest sensitivity. Solutions of substances which produce in man the taste sensations recognized as acid, bitter, salty and alkaline were applied in various concentrations. The gills fail usually before other parts, although all responses gradually weaken with increasing dilution.

From the foregoing tests it becomes evident that the rhinophore is not only extremely sensitive to chemical stimulation of diverse sorts, but that this sensitivity is only second to, if indeed it does not equal, that of the oral tentacles, which from their position might be suspected *a priori* of a specialized gustatory or common chemical function.

Olfactory stimulation. Saturated solutions in sea water of numerous essential oils and decoctions of decaying marine invertebrates were prepared and applied by the pipet method. The rhinophores react strongly to these solutions, but other parts of the body appear to be, so far as one can judge from the dissimilarity of the responses, equally sensitive. When a drop of oil is held for some time midway between the rhinophores no response ensues. If the rhinophore, or body, be touched gently with a drop of pure oil, the reaction is weaker than to a saturated solution. Here the number of sense organs stimulated is undoubtedly a complicating factor, yet there is suggested further that the response is one to an olfactory, rather than to an irritative or 'smarting' stimulus.

An essentially similar behavior to odorous substances was found in Chromadoris roseapicta, Elysia crispa and Fiona marina. Besides the rhinophores, Facelina goslingi possesses long, more or less dorsal tentacles, and short oral ones. The longer pair reacts more vigorously to solutions of the oils than do the rhinophores.

Summary. The entire body of Chromodoris zebra is sensitive to mechanical, common chemical, gustatory and olfactory stimuli. The head region is somewhat responsive to the application of increased temperature. Several other nudibranchs exhibit general olfactory sensitivity. Of the various parts of the body, the rhinophore is most sensitive to touch; is second, if not equal to the oral tentacle, in its response to chemical stimulation; and shares its sensitivity to odorous substances with the oral tentacle. In at least one species, Facelina, the long posterior tentacles react more vigorously to solutions of essential oils than do the rhinophores. Only to thermal stimulation is the rhinophore (of Chromodoris) clearly inferior in sensitivity. Hence

the so-called rhinophore, like the insect antenna, is a compound sense organ, for which the misleading term 'rhinophore' is highly inapt.

47. Paramœcium grown in pure cultures of bacteria. GEORGE O. HARGITT and WALTER W. FRAY, Syracuse University.

Identical hay-infusions, inoculated with bacteria of the air, hay, or tap-water, produced flora quite similar for air and hay inoculation, somewhat different for water inoculation. The bacteria present in the infusions after a growth of three weeks were somewhat different than at first; at the end of three months entirely different types of bacteria had developed and some of the original forms had disappeared. In general it was found that the bacteria present in the fresh cultures were more favorable as food, and those of a three months culture were generally unfavorable as food for Paramecium.

From fresh and old cultures, from normal and abnormal (fermenting and putrefying) cultures, over thirty different kinds of bacteria were isolated in pure cultures; of these eleven were identified and their morphological, cultural, and bio-chemical characteristics were thoroughly studied. Sister Paramecia were grown in pure cultures of these eleven kinds of bacteria and their favorableness or unfavorableness as food was determined by the rate of division of the protozoa. No single kind of bacteria was as satisfactory a food as a mixture of different kinds of bacteria. Some bacteria were so unsatisfactory as to cause the death of Paramecium more quickly than if the protozoa were grown in sterile water. Bacillus subtilis was the best single form for food; in some cases Paramecium feeding on them divided more rapidly, in other cases less rapidly than on a mixed diet.

By using bacteriological methods it was demonstrated that Paramecium could be rendered absolutely sterile by washing the animals through five or six changes of sterile fluid. All feeding tests were carried on with sterilized Paramecia of the same strain. All pipettes, slides, moist chambers, and the like were sterilized in a hot air sterilizer at a temperature of 150°C., or more. The culture medium used was made at one time, placed in test tubes and sterilized before the experiments were started; the fluids were therefore identical throughout the investigation. All external conditions were controlled, or at least were the same for all cultures, so that the only difference between the experimental cultures was in the food supplied to Paramecium.

The feeding experiments were conducted as follows: A sterile depression slide was filled with hay infusion in which were growing bacteria of a single sort (a pure culture of bacteria). A single Paramecium was introduced and the slide placed in a sterile petri-dish, the atmosphere of which was kept moist by a small amount of sterile water. Each day some of the originally prepared, standard, hay-infusion, freshly inoculated with the desired bacteria, was placed in a slide in a sterile moist chamber and one Paramecium from the slide culture of the previous day transferred to it with a sterile pipette. The slide culture for a feeding experiment was usually carried for a period of ten days or two weeks.

If proper precautions were taken the culture fluid of the slide at the end of the period of experimentation was generally found to contain only the single kind of bacteria originally introduced. This was determined in each case by making an agar plate of the culture fluid at the end of the experiment. Occasionally strange bacteria gained entrance and contaminated the culture fluid, but the contamination was so slight that the diet of Paramecium was probably not modified to any extent. In the most extreme case a count of the bacteria at the end of the experiment (two weeks) in the slide culture showed the contaminating bacteria present in the ratio of 1 to 350 of the form originally introduced.

The results of the feeding experiments are believed, therefore, to be accurate indications of the effect of different kinds of bacteria as food for Paramecium.

48. Recognition among insects. N. E. McIndoo, Bureau of Entomology, Washington, D. C.

It has always been a matter of conjecture as to how the various lower animals recognize one another and by what means the sexes of any species distinguish each other. The senses of sight and touch are undoubtedly used considerably for this purpose, but it is probably true that the olfactory sense is the most important factor. Jaeger (Zeitsch. f. wiss. Zool., Bd. 27, 1876, p. 322) goes so far as to assert that most animals emit odors peculiar not only to the individual, variety, race, and species, but also to the genus, family, order and class, and that these odors are the chief means by which one animal recognizes other animals.

The experimental results embodied in the present paper deal only with the odors emitted by honey bees. Some of the results are not conclusive, although the following are now fairly well established by von Buttel-Reepen and the present writer.

It is certain that a queen gives off an odor, and it seems reasonable that the odors from any two queens would be slightly different. All the offspring of the same queen seems to inherit a particular odor from her. This odor, called the family odor, perhaps plays little or no use in the lives of bees, for it is certainly masked by the other odors. Drones seem to emit an odor peculiar to their sex, but little can be said about it. It seems certain that each worker emits an individual odor which is different from that of any other worker. It is also probable that the wax generators and nurse bees emit odors slightly different from those of the field bees.

Of all the odors produced by bees, the hive odor is probably the most important. It seems to be the fundamental factor or principle upon which the social life of a colony of bees depends, and perhaps upon which the social habit was acquired; without it a colony of bees could not exist. The hive odor is composed chiefly of the individual odors from all the workers in a hive, and is supplemented by the odors from the queen, drones, combs, frames and walls of the hive, etc. From

this definition it is easily understood why no two colonies have the same hive odor. The hive odor of a queenless colony is perhaps considerably different from that of a colony which has a queen. The absence of a queen odor in the hive odor probably explains why the workers in a queenless colony are irritable and never work normally. All the bees—workers, queen and drones—in a colony carry the hive odor of that colony on their bodies among the hairs. This odor serves as a sign or mark by which all the occupants of a hive "know" one another. Since the queen and drones are "aristocrats," they seem to disregard the sign that has been thrust upon them, but whenever a queen enters the wrong hive, she soon "realizes" that she wears the wrong badge. Worker bees returning to the hives from the fields pass the guards unmolested, because they carry the proper sign, although the hive odor that they carry is fainter than when they left the hive, and it is also partially masked by the odors from the nectar and pollen carried by these bees.

Bees kept in the open air for three days lose all the hive odor carried on their bodies, but each bee still emits its individual odor. When a colony is divided the hive odor in each half soon changes so that by the end of the third day the original colony possesses a hive odor so different from that of the other half of the colony, that when the workers are removed from the two new colonies and are placed together in observation cases, they fight one another as though they had been separated all their lives.

While a foreign hive odor calls forth the fighting spirit in workers, the queen odor always seems pleasant to workers regardless of whether the queen belongs to their hive or to another hive. Even though the queen odor forms a part of the hive odor, it is probable that this odor to the workers stands out quite prominently from the hive odor. That workers do not miss their queen for some time after she has left the hive, indicates that her odor thoroughly permeates the hive odor and that whenever this odor grows faint the workers "know" that she is not among them.

There has been much speculation concerning the ruling spirit or power in a colony of bees. The writer is inclined to believe that a normal hive odor serves such a purpose. The hive odor is a means of preserving the social life of the bees from without, the queen odor which is a part of it insures continuation of the social life within. As already stated the workers "know" their hive-mates by the hive odor they carry. This odor insures harmony and a united defense when an enemy attacks the colony. The queen odor constantly informs the workers that their queen is present, and even though she does not rule, her presence means everything to the bees in perpetuating the colony. Thus by obeying the stimuli of the hive odor and queen odor, and being guided by instinct, a colony of bees perhaps could not want a better ruler.

49. The rate of locomotion of vanessa antiopa in different luminous intensities and its bearing on the "continuous action theory" of orientation. Wm. L. Dolley, Jr., Randolph-Macon College.

If orientation in light is dependent upon the stimulation of both retinas by equal amounts of light, energy as is held by Loeb and his "continuous action theory," butterflies should move more rapidly in bright light than in weak. To test this the rate of movement of 10 specimens of Vanessa antiopa in each of two lights, one about 2,000 times stronger than the other, was ascertained. They did not move faster in the bright light than in the weak, but, on the contrary, 70 per cent of the insects actually moved more rapidly in the weak light than they did in the strong. These results support those presented previously which indicated that the orientation of Vanessa in light cannot be accounted for on the basis of Loeb's theory. Moreover, some positive evidence has been obtained in favor of the theory that orientation is dependent upon the time rate of change of intensity, since the results of some experiments seem to indicate that Vanessa moves faster in intermittent light than in continuous light.

50. A super-organ for the expansion of Renilla. G. H. Parker, Harvard University.

The Pennatulid Renilla, in its adult state, consists of a flat, kidney-shaped portion, representing the expanded rachis, and a peduncle of striking proportions. The dorsal surface of the rachis is said to carry three kinds of zooids: large autozooids capable of considerable expansion and generally scattered over the surface; small siphonozooids also generally scattered; and a single axial zooid situated on the axis of the colony and not far from its middle. The peduncle has long been known to be divided longitudinally into two chambers by a delicate membrane.

If a specimen of Renilla is roughly handled, all its zooids contract and its volume is much diminished by the loss of seawater. Reëxpansion is accomplished by the peristaltic action of the walls of the peduncle whereby the colony becomes refilled with seawater. The seawater enters through the mouth of the axial zooid; it then passes down one chamber in the peduncle to the neighborhood of the distal end of that part where it crosses through apertures in the membrane to the opposite chamber. From this chamber it makes its way by appropriate channels to the various autozooids which are thus expanded. The pressure under which this water flows is due to the muscular contractions of the peduncle. The peduncle in Renilla, and probably in many other Pennatulids, is therefore an organ of expansion for the whole colony.

If the functional parts of protozoans are to be called organoids, and the functional parts of metazoan individuals organs, the functional parts of metazoan colonies, such as the peduncle of Renilla, may be called super-organs.

51. The photoreceptors of amphioxus.[1] W. J. Crozier, Bermuda Biological Station.

An incandescent filament appropriately mounted was substituted for the ocular on one limb of a binocular microscope; by means of this device it was possible to secure, with properly adjusted diaphragms, an intense beam of light, microscopic in diameter, which was focussed within or upon various portions of Branchiostoma carribaeum. The exact location of the light-spot, and the extent of light scattering by the tissues, were observed through the other tube of the binocular. Practically every portion of the body of a number of lancelets was examined in this way in a dark-room; precautions were taken to avoid mechanical stimulation, to which amphioxus is very sensitive in the dark. No responses were obtained except when the light was focussed upon or within the ventral half of the nerve cord. It was possible to prove, notably by experiments with individuals in which portions of the integument were thoroughly anaesthetised, that this stimulation did not concern photoreceptors in the skin.

The integument of amphioxus therefore contains no normal photoreceptors. As indicated by Parker's less precise tests, the optic cups within the nerve-tube are probably the light-sensitive organs in this animal. This conclusion is substantiated by the details of the illumination trials, and particularly by the demonstration of photomechanical changes in the pigment cups of the "Sehzellen." Some evidence was secured which points to the photosensitivity of the "dorsal Sehzellen" of Joseph. The region of the anterior pigment spot is insensitive to light.

52. The olfactory reactions of snails. Manton Copeland, Bowdoin College.

It is well known that certain snails have the habit of collecting about decaying organisms or living bivalve mollusks, in the latter case often causing considerable damage to oyster beds. The reactions to food of two species belonging to the genera Alectrion and Busycon (Sycotypus) were carefully studied with the view of determining the general nature of the response, the manner in which food is located and the sense organ concerned.

Alectrion which showed variation in its rheotropic reactions moved more often against the current when a dead fish was placed at the head of the stream, and extended its proboscis in search of food when stimulated with fish juice squirted from a pipette. Busycon exhibited similar reactions to an extract of oyster. Since the response was obtained from dilute juices emanating from distant food, it may be regarded as truly olfactory.

The tentacles of gasteropods have been described as olfactory organs, but both species studied showed the same type of reaction after their removal. The snails had the habit of burying themselves in the sand, leaving only the tips of their siphons exposed. Under such conditions they often came out of the sand when food juices were taken

[1] Contribution from the Biological Station for Research, No. 53.

into the siphons. It soon became evident, therefore, that the olfactory organ was situated either within the siphon or mantle chamber. Since Alectrion still reaction to juices after the greater portion of the siphon had been removed, it seemed probable that the osphradium was the olfactory receptor. This conclusion was substantiated by scraping away the osphradia from several specimens of Busycon, which then failed to show olfactory response, although they took food when it was tasted and in other ways exhibited normal behavior.

The way in which Busycon locates distant food through its olfactory sense was definitely determined. When the snail is moving the siphon is continually swinging from one side to the other. If the stimulus is applied when the siphon is at the end of its movement to the left the foot turns in the same direction, whereas it turns to the right if stimulation occurs at the termination of the dextral swing. There is no difficulty, therefore, in leading a snail in any direction over the floor of the aquarium or up its side by applying oyster juice to the tip of the siphon, provided the organ is first pointed in the direction which it is desired the animal shall follow. When two cheesecloth bags, one containing a piece of oyster, were fastened in front of and lateral to the siphon tip, one on the right the other on the left, the snail turned in the direction of the baited bag, in a single instance completing two and a half circles.

The foregoing experiments show that the snail instead of possessing the paired olfactory organs characteristic of most animals has a median one situtated near the base of the siphon. Accordingly, orientation to dilute chemical stimuli involves two distinct muscular activities, first a right and left swinging of the siphon preceding stimulation, and secondly a movement of the foot in the direction indicated by the siphon at the time it conducts the stimulating materials to the sense organ, the osphradium. By this prodecure the snail continues to move toward and finally arrives at the source of the stimulus, its food.

53. The reactions of the crimson-spotted newt, diemyctylus viridescens, to light. A. M. Reese, University of West Virginia.

1. Phototropic reactions of Diemyctylus are markedly negative; in 30 observations 251 were found in the dark to 95 in the light half of the aquarium.

2. At temperatures near freezing water the animals become so sluggish as to be more or less indifferent to light; if the temperature be raised to about 36°C. they become abnormally active, and are again indifferent to light; at 40°C. they are seriously affected or even killed.

3. These animals respond in the same way, though less markedly, when half of the aquarium is illumined from below.

4. Diemyctylus is positively phototactic towards even very weak daylight, such as is seen on a cloudy day 20 feet away from an ordinary window.

5. With a 25W 115V Tungsten light 6 inches from the end of the aquarium 298 animals faced the light to 90 that faced away from it;

and 244 were noted in the near half of the aquarium to 163 in the far half.

6. With an electric arc projection lantern 15 inches from the end of the aquarium 116 animals faced the light to 41 facing away; and 105 animals were in the near half to 60 in the distant half.

7. At low temperatures the phototactic response to white light is inhibited or even reversed; i.e., in 12 observations with the Tungsten light and a maximum water temperature of 11°C. 43 animals faced the light to 72 that faced away from it; and 48 were counted in the near half to 94 in the far half of the aquarium.

8. With an intense white light at each end of the aquarium the animals tend towards the less intense; if neither light be of great intensity, perhaps not reaching a certain optimum, the animals tend towards the more intense.

9. Reaction to pure red light is the same (though, perhaps, more marked) as to the white; i.e., 225 animals faced the light, in one experiment, to 46 that faced away from the light; and 221 were in the near half of the aquarium to 49 in the distant half.

10. Reactions to blue light are like those to red, but not so marked.

11. The attraction of green light is more marked than the blue but less marked than the red.

12. A small spot of white light from a micro-electric torch produced no effect when thrown on various parts of the body.

13. The animals responded promptly to a beam of sunlight, thrown on various parts of the body, either from above or below, by a small mirror; though if the mirror threw a beam of 5 mm. or less there was little or no response.

14. Animals experimented upon in their native pond, under as natural conditions as could be provided, gave essentially the same responses as described above to sunlight and to an acetylene light at night.

54. Reaction of the whip-tail scorpion to light. Bradley M. Patten, Laboratory of Histology and Embryology, School of Medicine, Western Reserve University.

The responses of whip-tail scorpions to light were studied with a view to establishing quantitatively, certain characteristic reactions. No attempt was made to treat exhaustively all phases of their behavior under the influence of light. The object was rather to obtain such reaction measurements as would best serve as a basis of comparison for subsequent work directed toward determining the relative effectiveness of the various parts of their complex photoreceptive mechanism.

Reactions to photic stimuli of known intensities were recorded in terms of the induced angular deflections from an initial direction of locomotion. The results obtained may be summarized as follows:

1. The threshold for the kinetic effect of light was at about 0.16 candle meters. The response was clearly negative to all intensities which induced locomotion. Up to an intensity of 1 candle meter the amplitude of the reaction increased rapidly. In the intensities above 1 candle meter the increase in deflection was much more gradual.

2. When started heading away from the source, in a horizontal beam of light of 120 candle meters, animals continued to move along the path of the rays. In 40 trails the average was within 0.6 of a degree of the central ray of the beam.

3. When subjected to a light of 120 candle meters acting on them from the side, the scorpions turned and moved away from the light. The average deflection was 65.8 degrees.

4. When subjected to balanced, opposed lights each delivering an illumination of 120 candle meters, the average trail was within 3.7 degrees of the norm to the line connecting the sources of light.

5. When started directly toward a light giving an illumination of 120 candle meters, the scorpions turned and moved away from the source. The average deflection was 140.4 degrees.

6. Unilateral elimination of any part of the photorecptive mechanism caused an unbalancing of subsequent reactions. The extent of the unbalance was proportional to the extent of the interference with the receptors.

With regard to the method of orientation these results point to the conclusion that the negative reactions of the whip-tail scorpion to light, depend on a tendency on the part of the animal to attain and maintain bilateral balance of stimulation. Moreover, there are, in this form, no indications that rapid changes of light intensity are necessary to the attainment of orientation. There would seem to be no doubt that light of constant intensity acts as a stimulus. It is apparent, also, that the stimulating effect of light of relatively constant intensity is a prime factor in bringing about and maintaining orientation.

55. The effect of light and dark upon the eye of Prorhynchus applanatus kennel. W. A. KEPNER and A. M. FOSHEE, University of Virginia.

1. Stimulation by light results in a contraction of the accessory cell or pigment-cell.

In sustained darkness the cytoplasmic lamellae of the pigment-cell open up or move apart, resulting in the expansion of the cell.

2. The three cytoplasmic regions of the retinula or visual cell show more or less marked changes in response to light and darkness. The nucleus-bearing part of the visual cell is somewhat widened in the dark. The refractive, middle segment-analagous to an ellipsoid of a vertebrate retinula—disappears in continuous illumination and is most conspicuous in eyes that have been subjected to optimum illumination. The rhabdome in light adapted material is a rounded cone-shaped body, while in dark adapted eyes it is an elongated trough-like structure with its long dimension directed parallel to the axis of the body of the animal.

3. Despite the analogy that is apparent between the structure of the retinula of a vertebrate and that of Prorhynchus, there is no analogy in functional changes shown. In the former it is the myoid that most markedly changes form, in the latter it the rhabdome is most conspicuously modified in response to light and darkness.

56. Experimental control of endomixis in paramecium. R. T. YOUNG, University of North Dakota.

The nuclear phenomena in several lines of Paramecium have been observed for a six months' period, during which time several endomixes occurred. The frequency of their occurrence, as measured by the number of generations ensuing between two, may be increased in various ways—by the use of old culture medium, and increase of temperature. Attempts to induce endomixis by the use of ammonia, alcohol, strychnine, nicotine and urea were unavailing. Endomixis is a normal regulatory process in Paramecium, not however necessarily associated with depression periods.

57. Orientation to light in planaria n. sp. and the function of the eyes. W. H. TALIAFERRO, Johns Hopkins University, (Introduced by Dr. S. O. Mast).

This work is an attempt to correlate an experimental study of the organs involved in orientation to light in Planaria n. sp. with their histological structure. In the present study we are interested primarily in the eyes.

All operations were performed upon animals anesthetized with carbon dioxide, with the aid of a knife constructed from fragments of safety razor blades. By means of such technique entire or parts of an eye can be removed. In all cases involving operations, after the behavior of an individual was observed, it was fixed and sectioned in order to ascertain the extent of the injury. The records of only those specimens which showed no injury to adjacent organs were used.

The eye of Planaria n. sp. is a typical tricladian eye. It consists of a pigment cup with its mouth opening laterally, anteriorly, and slightly dorsally. This pigment cup has its cavity filled with numerous rhabdomes which are connected by nerve processes with the central nervous system.

Normal specimens of this planarian orient fairly precisely. They are negative and when laterally stimulated turn directly away from the source of light. When, however, a specimen has proceeded a short distance directly away from the light it tends to wander to the right or left. If, in this wandering it turns far enough to allow the rays of light to enter the pigment cup, it suddenly re-orients, suggesting strongly that once the animal is oriented it receives no stimulation unless it leaves the path of orientation. This is opposed to the "continuous action" theory of orientation. During the whole process of orientation the specimen at irregular intervals twists its anterior end so that the ventral side tends to be placed dorsally. This twisting reflex apparently plays no part in normal orientation but has a very definite function in the orientation of forms with one eye removed.

Animals with both eyes removed (without disturbing adjacent organs, such as the nervous system) show absolutely no orientation to light, but they still respond to change of illumination and come to rest in the area of least intensity. From this we may conclude that the directive stimulation of light is received through the eyes.

Animals with one eye removed travel about essentially like normal specimens. There is no evidence whatever of circus movements. If such specimens are stimulated with a horizontal beam of light upon the normal side they turn directly away from the light as do the normal specimens. If the light strikes the "blind" side they do not turn unless in wandering from the path of orientation toward the "blind" side, they swerve enough to cause the light to enter the pigment cup of the remaining eye, or unless during the 'twisting' reflex they twist the head enough to allow the light to enter the eye, or, finally, unless the source of light is raised to an almost vertical position so that again the light enters the pigment cup of the eye. If any one of these conditions is fulfilled they turn directly away from the light, i.e., toward the side having the functional eye. This demonstrates that if the light strikes certain parts of the eye the animal turns toward the stimulated eye, whereas if the light strikes other parts the animal turns away from the stimulated eye.

A number of experiments were carried out to determine the exact extent of these two localized sensory regions. In these experiments it was found that if a beam of light strikes the rhabdomes that lie on the ventral or dorsal lips or the posterior part of the pigment cup the animal turns *toward* the stimulated eye. On the other hand, if it strikes the rhabdomes of the central cavity or anterior part of the pigment cup the animal turns *away* from the stimulated eye.

The above experiments are of further value in that they show that the rhabdomes are not stimulated when the pigment cup lies between them and the source of light. The pigment cups are so placed that once an animal is oriented in relation to a horizontal beam of light, none of it can stimulate any of the rhabdomes unless it does pass through the pigment cup. Since this is so it seems to support the conclusion that once an animal is oriented it receives no stimulation until it leaves the path of orientation sufficiently to allow the light to enter the mouth of the pigment cup.

In a number of animals the posterior part of the eye was removed thus exposing the central rhabdomes to light from behind. These rhabdomes are the ones that in normal orientation cause the animal to turn away from the stimulated eye. Such specimens, however, orient in the same manner as normal ones and proceed away from the light in the same manner although these central rhabdomes are constantly exposed to the light. In another series of experiments the eyes of animals, with both eyes removed, were allowed to partially regenerate. The reactions to light of these specimens were tested at short intervals, and as soon as a given specimen oriented it was fixed and the histology of the eye studied in order to ascertain those parts of the eye necessary for orientation. The results obtained in these experiments show that orientation may occur as soon as a few rhabdomes are formed and that it bears no relation to the position or extent of development of the pigment cup. The results even suggest that the pigment cup is not necessary at all for orientation.

We must conclude therefore that the pigment cup has no function of localizing the otherwise general light stimulation as suggested by Hesse ('97). In other words that the directive stimulation of light does not depend upon the differential shading of the rhabdomes by the pigment cup. And we must also conclude that the light can stimulate a given rhabdome only when it passes through in a certain direction, viz., through some structurally defined axis.

A study of the histology of the eye not only supports the last contention but defines the axis along which the light must pass. By making reconstructions of the eye it was found that all of the rhabdomes in a given localized sensory region are so placed that their longitudinal axes always coincide with the direction of the rays of light that normally stimulate this given region. The rhabdome itself shows an optically denser region in its outer end as described in Prorhynchus applanatus by Kepner and Taliaferro ('16). This region, because of its shape and density, must have some effect upon the rays of light if they pass through the longitudinal axis, which it cannot have if they pass through in any other direction.

To sum up, the following statements may be made. The directive stimulation of light in Planaria n. sp. is received through the eyes. The sensory part of these organs is composed of rhabdomes. These are so arranged as to form two sensory regions in the eye. Stimulation of one of these regions causes the animal to turn away from, and stimulation of the other region causes it to turn toward, the stimulated eye. The rhabdomes of each of these regions are so placed that the light which normally stimulates a given region has to pass through the longitudinal axis of the rhabdomes. If, however, the normal course of events is altered (by removing part of the pigment cup, etc.) and the light is allowed to pass through some other axis of the rhabdomes, the latter receive no stimulation. As to the function of the pigment cup, none but regative evidence has as yet been found.

58. Sense of taste in Nereis virens. Alfred O. Gross, Bowdoin College.

The food of the adults of Nereis virens was investigated by an examination of specimens secured in various situations of several localities. In all cases it was found to be made up almost entirely of vegetable matter—animal life as a food was merely incidental.

Nereis exhibits no marked responsiveness to food material, but was very strongly negatively chemotrophic to even the weak solutions of acids, alkalies and hydroxides in sea water. The worms were tested by placing them on a narrow paraffin dam, built across a rubber developing tray, in such a way that they were free to withdraw into the sea water on one side or crawl into the sea water containing the stimulating substance on the other side. The average time required for each of a series of 24 animals to withdraw from various strengths of solutions was determined under conditions controlled for the factors of light and temperature. The cirri, palps and tentacles were then cut off from all of the series excepting those used as a control. Tests

made after the animals had fully recovered from the operation showed the worms to have a decided increase in the time required to withdraw from the stimulating solution. After the organs regenerated on the operated animals the reaction time was practically equal to that of the normal individuals. A large number of experiments were conducted in which only one or various combinations of organs were removed. In all cases the average time for the worms to withdraw was determined before and after the organs were destroyed and again when the parts had regenerated.

The chemical sense was found to be localized to definite regions, and apparently depends on the presence of clusters of sense cells.

59. The influence of the marginal sense organs on functional activity in Cassiopea xamachana Bigelow. LEWIS R. CARY, Princeton University.

A. THE INFLUENCE OF THE SENSE ORGANS ON THE RATE OF REGENERATION

Previous studies have demonstrated a marked influence of the sense organs on the rate of regeneration in Cassiopea, when halves of the same disk are used for comparison. As this influence is most marked in the earlier stages of regeneration several series of disks were prepared by first separating each disk into halves and then removing the sense organs from one of each pair of half-disks at varying intervals after the first operation. If the sense organs were removed within less than twenty-four hours after the first operation the regeneration would be most rapid from the half upon which the sense organs remained. When the sense organs were allowed to remain on both half-disks for twenty-six or more hours before the second operation the amount of regeneration was equal for both halves.

B. THE INFLUENCE OF THE SENSE ORGANS ON THE LOSS OF WEIGHT IN STARVING DISKS OF CASSIOPEA

When an entire medusa, or the separated disk of Cassiopea is starved in sea water from which all food material has been removed by careful filtration, the loss of weight follows a curve that has the mathematical formula $y = W\ (1-a)^x$, in which W is the original weight, x the number of days of starvation and a a constant the "coefficient of negative metabolism." While the value of a in the equation above will differ in experiments involving differing conditions of light, regeneration, density of the water, etc., this formula gives a very close approximation to the observed result in all cases.

In the following experiments the disks were prepared in such a manner that they fell into one of three groups. In the first group one half of each disk retained its sense organs, while these structures had been removed from its mate (active and inactive series). In the second group one half-disk retained its sense organs, while after the removal

of these structures from the other half its muscles were activated by a circuit wave of contraction started by an induction shock, (active and activated series). In the third group activated and inactive half-disks were compared.

The greatest loss of weight was shown by the half-disks with sense organs, a considerably smaller loss by the activated specimens and the smallest loss by the inactive group. In every instance these results follow very closely those obtained when the rate of regeneration was used as the standard of measurement.

A summary of the results of the entire series of experiments is shown in the following tables.

TABLE 1

Loss of weight in active and inactive half-disks

DAYS AFTER OPERATION	WEIGHT OF HALF WITH SENSE ORGANS	WEIGHT OF HALF WITHOUT SENSE ORGANS
0	100.00	100.00
1	76.84	81.81
2	66.72	71.27
3	58.54	64.09
4	55.27	55.41

TABLE 2

Loss of weight in active and activated half-disks

DAYS AFTER OPERATION	WEIGHT OF HALF WITH SENSE ORGANS	WEIGHT OF ACTIVATED HALF
0	100.00	100.00
1	76.29	79.41
2	67.18	70.58
3	59.76	61.99
4	55.88	57.18

In both these experiments the weight is reduced to 100 grams for the original weight of the series. The comparison of the loss of the activated disks with the inactive disks can be made by using the right hand columns in tables 1 and 2.

In the experiments where active and activated disks were used the pulsation rate of the latter was on the average about three times that of the former at the beginning of any experiment. In the later stages the difference in the pulsation rate became greater, until at the close of the first twenty-four hours the activated halves were pulsating ten times as fast as the halves the pulsation of which were under the control of the sense organs. This change in the realtiverates of pulsation comes about both through a decline in the rate of the active half-disks and in increase in the rate of the activated halves.

Simultaneous kymograph records of the pulsations of the halves of the same disk, one with its sense organs and the other with an entrapped wave of contraction in its subumbrella muscles, showed that

when a like series of cuts were made in the subumbrella tissues of each half the amplitudes of the contractions were equal so that pulsation rate affords a true measure of the muscular activity of each half-disk.

C. THE INFLUENCE OF THE SENSE ORGANS ON THE TOTAL METABOLISM OF CASSIOPEA, AS MEASURED BY CARBON DIOXIDE PRODUCTION

Since in experiments where either the rate of regeneration or the loss of weight during starvation had been used as the standard of measurement it had been shown that there must be some other more important factor involved than that of muscular activity, the total metabolism of half-disks prepared as in the former experiments was determined. Here again the muscular activity was the most apparent difference between the half disks.

To measure the total metabolism (respiratory activity) the half-disks were put separately into jars of fresh sea water, each containing 1200 cc., provided with a clamped top so that none of the gases could escape. After equal intervals of time each half of any pair of disks was removed from its jar and the amount of CO_2 that had been given off determined by ascertaining the change in the hydrogen ion concentration that had taken place in the sea water.

Under these conditions the pulsation rate of any half disk first increased for a short time under the stimulating effects of the increase of hydrogen ions. There then followed a progressive decrease in the pulsation rate until finally the disks became quiescent from the anaesthetic effect of the CO_2, which they had themselves given off. In nearly all instances the activated half-disk was the first to succumb to the CO_2, and the decline in its rate of pulsation was quite steady after the preliminary rise in response to the first increase in acidity. The half-disk with sense organs was always very erratic in its pulsations and after a long quiscent period would frequently, just before complete anaesthesia, pulsate for a few moments at a rate several times that shown under the influence of the first CO_2 stimulation.

When the jars in which these experiments were carried out were allowed to remain in daylight the disks would continue to pulsate for several days, as the CO_2 would be for the most part used up in the metabolism of the symbiotic algae which are so abundant in the tissues of Cassiopea.

The normal reaction of the sea water at Tortugas varies from PH 8.1 to PH 8.2 (CH 8×10^{-9} to 6.3×10^{-9}). After a half-disk had been kept in one of the closed jars for several hours the reaction would be changed to PH 7.9 (approximately) after which the change was very slow, anesthesia soon following. Using the same volume of sea water it was found that the addition of from 4 to 5 cc. of pure CO_2 would bring about the same change in the reaction of the water as that caused by the respiration of the half medusa disk.

The amount of CO_2 given off from the active or activated half-disks seldom varied more than 0.1 of the PH unit, and in most experiments

the more slowly pulsating half with its sense organs had the higher rate of metabolism. The muscular activity, on the other hand, was in the proportion of one to three at the start of the experiment, and rose to about one to ten during the experiment, the activated half-disk having always the higher rate.

60. The relation between the hydrogen ion concentration of sperm suspensions and their fertilizing power. EDWIN J. COHN, University of Chicago. (Introduced by Frank R. Lillie.)

The activity of the spermatozoa of Arbacia is a function of the hydrogen ion concentration. In sea water less alkaline than 0.5×10^{-7} sperm, are apparently non-motile. In such a medium, however, they live very much longer than in natural sea water, as measured (a) by their power to fertilize ripe eggs of the same species and, (b) by the dissolution of their protoplasm. In sea water more alkaline than the ocean (i.e., H.I.C. of $.08 \times 10^{-7}$) the life of the sperm is shortened.

The often repeated observation that more concentrated sperm suspensions live longer, is also attributable for the most part, to the greater hydrogen ion concentrations in the denser suspensions. For, the more concentrated the suspension, the more carbon dioxide is at first produced by the sperm themselves. The ionization of the carbonic acid thus formed increases the hydrogen ion concentration of the suspension, and decreases the activity of the sperm. Measurements of the total carbon dioxide production of sperm suspensions of varying concentration show that sperm that live twenty-four hours produce no more carbon dioxide than sperm that live for only four hours. Using the carbon dioxide production as the criterion, we must conclude that the activity of the sperm is limited. Therefore, sperm that have been in alkaline sea water have a greater fertilizing power, but for a shorter time, than sperm that have been in unmodified sea water, while sperm that have been in acidified sea water, where they have been relatively inactive, retain their power to fertilize for a much longer period.

61. Experimental study of ageing eggs and sperm and of their development. A. J. GOLDFARB, College of the City of New York.

For the last two years experiments were made with the sea-urchin eggs of Toxopneustes and Hippanoe of the Florida coast and Arbacia of the Massachusetts coast.

1. The first series of experiments were made with a view towards obtaining experimental conditions that were optimum and that gave the least variability for freshly removed eggs and sperm, from freshly collected sea urchins.

2. Surprisingly large differences were observed among the different females particularly Toxopneustes and Hippanoe. Such individual variability involved (a) size of eggs; (b) presence or absence of jelly; (c) rate of membrane formation; (d) character of membrane; (e) rate and total cleavage; (f) character of cleavage.

3. By means of one or more of these criteria it was possible to grade the different freshly collected females according to the physiologic

condition of their eggs. Eggs of similar physiologic condition showed a minimum variability and the highest correlation with respect to these six categories.

4. When eggs and sperm were removed from their respective bodies and kept under optimum laboratory conditions; the same physiologic changes which had begun within the bodies of the urchins continued outside of the body.

5. With increasing age outside of the body, the eggs showed progressive changes in (a) size; (b) loss of jelly; (c) retardation of membrane formation; (d) decreased extension of membrane formation; (e) decreased percentage of cleavage, (f) decreased rate of cleavage.

6. These changes were closely proportional to the time after removal of the eggs from the urchins. Knowing the age one could predict the physiological and developmental changes in the eggs; and vice versa knowing the condition of the eggs one could estimate their age.

7. The physiologic and developmental changes enumerated above were correlated.

8. Further studies made clear in what regards ageing eggs fertilized by fresh sperm, differed from ageing sperm by fresh eggs, and these in turn from eggs and sperm that aged synchronously. This also made possible the determination of the maximum longevity of eggs and of sperm.

9. Other changes consequent upon ageing of eggs suggested the nature of the chemico-physical agencies involved in the ageing process, namely, (a) agglutination and fusion of eggs; (b) tendency to develop irregularly; (c) tendency of blastomeres to separate.

10. These changes suggested that the excess free HO ions in sea water was one agency and probably a very important one in causing the dissolution of the jelly, the changes in the permeability of the cortical layer of the eggs, the changes in size and all the other changes mentioned, that follow upon long exposure to the free HO ions.

11. If these ions are involved in the ageing process, one should be able to age eggs precociously with hyperalkaline sea water, and one should be able to retard their ageing with sea water made neutral. These experiments were repeatedly made. Eggs were made to age precociously and show all the physiologie and developmental changes enumerated above with hyperalkaline sea water, or their ageing was retarded more surprisingly by removing excess HO ions.

12. The longevity of the eggs were increased either by reduction of respiration by KCN as proposed by Loeb, Lyon and others, or by eliminating the effect of the free HO ions of sea water.

13. Other changes involving the metabolism of the eggs and sperm will be reported elsewhere.

62. The consumption of oxygen during the development of fundulus heteroclitus. GEORGE G. SCOTT, College of the City of New York, and WM. E. KELLICOTT, Goucher College.

The energy for development is derived from the oxidation of nutrient materials. This energy is partly consumed in the *processes* of develop-

ment, and is partly represented by the chemical structure of the differentiated substances of the organs and tissues of the embryo as contrasted with that of the yolk-substance. The rate at which oxygen is consumed is an index of the rate at which all of these changes occur.

During the summer of 1916 the authors, working jointly at the Bureau of Fisheries and the Marine Biological Laboratory, Woods Hole, carried on a series of observations on the rate of oxygen consumption during the entire developmental period of Fundulus heteroclitus, from fertilization until ten days after hatching. Seven distinct series including about 11,000 eggs were observed, some of which were combined and others divided during the period of observation. Methods of study were improved during the course of the experiments, but some series were treated uniformly throughout.

Known numbers of eggs were placed in air-tight containers, immersed in running sea-water. Temperatures thus varied only slowly between limits of 19.4 and 21.4°C. The water covering the eggs was renewed at appropriate intervals, samples being taken at the beginning and end of each interval. The amount of oxygen present in these samples was determined by the Winkler method. Altogether about 700 determinations were made. From these determinations the amount of oxygen consumed was calculated and expressed in cubic centimeters consumed per thousand eggs per hour. While this preliminary report is based upon the study of only a part of our data and is therefore subject to modification in details, certain essential facts may be stated.

The amount of water allowed per egg per hour was varied considerably in different series. Two series were kept enclosed throughout the entire period to hatching, save for the brief intervals of sampling; others were sealed for observation only a few hours at a time and during the intervals between these periods were kept in large flat dishes, loosely covered.

The duration of the period before hatching varies, not only with temperature, but particularly with the amount of oxygen actually available. The total amount of oxygen consumed and the relative rates of its consumption during different phases of development do not vary materially, so long as a certain minimum is not passed, whether the average age at hatching be 17 days (normal at the temperature used) or more than 40 days.

The more striking features in the varying rate of oxygen consumption are best shown in graphic form [see chart].

During the early stages of development—cleavage, embryo-formation, etc.—the hourly consumption of oxygen is less than 0.10 cc. per thousand eggs. A marked rise in the rate occurs at the time the circulation is established, after which it remains practically constant, though with an upward trend, until shortly before the time of hatching.

Approximately 80 cc. of oxygen are consumed by 1000 eggs up to this time. At hatching and thereafter the increased energy demands incident to muscular activity are reflected in a very great increase in oxygen consumption. During the hours immediately after hatching the

rate rises to about 0.7 cc. per hour per thousand, which increases steadily to more than 1.75 cc. about six days after hatching. By that time the yolk is almost wholly absorbed and the rate of consumption falls off rapidly, in the absence of a food supply.

Determinations were made of the amount of protoplasm and of yolk present at the commencement of development and of the weight of the embryo after hatching. During early cleavage, when the amount of protoplasm can be accurately determined, a thousand eggs contain 0.12 cc. protoplasm and 2.65 cc. yolk-material, a total weight of approximately 2.9 grams. At six days after hatching 1000 larvae weigh approximately 1.8 grams, nearly all of which consists of differentiated tissues. There is thus a loss of about 1.1 grams or 38 per cent of the initial weight of protoplasm and yolk. In effecting this transformation roughly 270 cc. of oxygen are consumed, that is, a little more than 0.25 cc. per egg.

63. A study of broodiness in the Rhode Island red breed of domestic fowl.
H. D. Goodale, Massachusetts Agricultural Experiment Station.
(To be read by title.)

In broody races of domestic fowl, such as the Rhode Island Reds, a pullet lays a variable number of eggs and then exhibits a desire to incubate them. When poultry is kept for eggs it is the practice of poultrymen to prevent the hen from gratifying her desire. Under such circumstances manifestations of broodiness disappear after a few days and after a period of variable length the hen begins laying again. This time only a comparatively few eggs are produced before the manifestations of broodiness reappear with consequent cessation of production. This cycle of alternate periods of production and non-production is repeated about once in 35 days until late summer or fall when production ceases until sometime in the winter or spring, when they are resumed. The present study is concerned with the relation of the various parts of the cycle to each other, their distributions in time and the effect of broodiness on egg production.

The results of most general interest are as follows: The length of the period before the first broody period appears may vary from a month up to two or even more years, while a very small per cent have never exhibited signs of broodiness. Ninety-five per cent, however, of the birds go broody before July 1 of their pullet year. The number of broody periods depends in part on the data of the first broody period and in part on the time the bird stops laying in the fall and may vary from one to eleven times during the first year. In the second year, broody periods begin as soon as the bird lays a comparatively few eggs.

The effect of broodiness on egg production is very marked, for if the rate of production (eggs divided by time in days) before the first broody period be compared with that for the remainder of the year, it is found that, on the average, production drops about 40 per cent. Other things being equal, then, broodiness lowers annual production

very markedly in this breed. The statistical constants for other phases of broodiness have been calculated and will be published as soon as possible.

Clear evidence that it will be possible to separate a strain of non-broody birds of this breed has been obtained, if indeed the strain has not already been established.

64. The vitality of cysts of Didinium nasutum. S. O. Mast. Johns Hopkins University.

Didinia cysts which had formed about the middle of June, 1910, were put into a 10 cc. vial May 31, 1911. The vial was then sealed air-tight. Cysts were taken from this vial from time to time, usually once a year, and tested for vitality by adding them to vigorous cultures of paramecia. The last test was made in March, 1915, nearly five years after the cysts had formed. In all of these tests some active didinia were obtained. Only a very small per cent of the cysts developed in any of the tests and in the last one this percentage seemed to be considerably smaller than in the others. In this test only a very few didinia came out but these developed rapidly and produced a very vigorous race which was normal in every respect. Didinia cysts can, therefore, retain vitality for at least five years. All of the cysts were used in the last test so that it was impossible to carry the experiment further.

Drying in ordinary atmospheric conditions does not destroy the cysts. In fact, there is some evidence which indicates that they would live longer dry than in a solution.

65. The reactions of Pelomyxa Carolinensis Wilson to food. By W. A. Kepner and J. G. Edwards, (University of Virginia).

These multinucleated rhizopods feed upon both animals and plants. Their food consists, so far as our observations go, of nematodes, ciliates, flagellates, diatoms and desmids. They show a preference for ciliates and flagellates, being very fond of Chilomonas paramecium and Paramecium caudatum.

There are three factors involved when all the effective stimulation of Pelomyxa to food-reaction are considered. These are (a) contact with bodies, (b) play of currents of water upon the rhizopods, and (c) chemical agencies, such as oxygen given off by green plants and carbon dioxide given off by bacteria and animals. Perhaps the most potent of these factors in determining which of the two types of food-reactions will be carried out is that presented by the currents of water set up by the play of cilia or flagella of animals and plants.

In reacting to objects of food, that give off currents in water and are able to dart away, the Pelomyxa avoids producing on the prey an effective stimulus by making a wide detour about the apparently quiet specimen. This represents one of the two types of food-reaction of Pelomyxa that we have observed.

In reacting to objects that are stationary and give off no currents in the water, the Pelomyxa applies itself intimately to the surface of

the object as it is being ingested. This represents the second type of Pelomyxa's food-reaction.

The details of the type of reaction involved when the Pelomyxa is reacting to an object, that is lashing its cilia or flagella and but for thus disturbing the water is otherwise quiet, are highly variable. Its reaction to such an object is modified to meet the conditions presented by each situation. For example, if Paramecium or Chilomonas lie in the open, it is surrounded on all sides by the advancing Pelomyxa; if the Paramecium or Chilomonas lie by a desmid, a psuedopod will be thrown up in such manner as to enclose the prey between the pseudopod and the desmid. In this manner the prey becomes entrapped between the advancing pseudopod of the rhizopod and the desmid. In this trap it is held until the pseudopod bends back upon the prey and encircles it on all sides leaving the desmid, which has been used as an aid in catching the protozoon, behind when the food vacuole has been completed and the animal is ingested.

The complex reaction to a highly motile, but apparently quiet protozoon may be arrested and reversed, if the prey escape; or it may advance until the acquired impetus of a sustained reaction has been spent, in some cases resulting in a fully formed food-vacuole.

Pelomyxa, when first stimulated by Paramecia that are actively darting about, reacts by sending out a flood of cytoplasm at the point of collision with the ciliate. Eventually, however, the reaction of the hungry rhizopod to the Paramecia is changed, so that it becomes less vigorous and, one could almost say, more cautious. After fifteen minutes of bombardment by the Paramecia the Pelomyxa ceases to present this futile flooding of cytoplasm and settles down to the more deliberate reactions characteristic of it when it feeds upon ciliates.

The details of the manner in which each peculiar situation is met when Pelomyxa reacts to food are so varied as that no theory yet advanced for the explanation of pseudopod-formation or food-reaction promises to satisfactorily explain them.

66. The significance of conjugation and encystment in Didinium nasutum.

S. O. Mast, Johns Hopkins University.

In April, 1910, a pedigree culture consisting of two groups of four lines of didinia was isolated. In one of the groups conjugation occurred at the time of isolation in the other group it did not. From the offspring of the latter other groups of lines were from time to time isolated, some immediately after conjugation, others immediately after encystment, and still others without either conjugation or encystment. These various groups, in isolation cultures, were carried along in parallel series, so that at any given time the number of generations which had been produced since conjugation and encystment had occurred in the different groups differed, in some instances but little in others very much. Thus the cultures were continued, with certain intermissions, until May, 1914.

At the close of the experiment there had been produced in one of the groups an average of 1646 generations without conjugation, and earlier

the same group of lines had passed through 1035 generations without encystment. The stock became very weak toward the close but it did not die out, and, of course, it is not known how much longer it would have survived. The fact that it continued so long without conjugation or encystment seems to indicate that these processes are not necessary for continued existence.

The specimens in all of the groups were treated as nearly alike as possible. They were all fed on paramecia from the same jars, subjected to the same temperature and kept in the same sort of solution. Consequently since all originated in the same individual they differed at any given time, merely in the number of generations produced since conjugation or encystment had occurred. If, therefore, these processes cause an increase in the rate of fission as Calkins maintains, or if conjugation causes a decrease in the rate of fission and an increase in death-rate and in the variability in the rate of fission as Jennings maintains, it should become evident in a comparative study of the characteristics of the individuals found in the different groups at any given time. Such a study shows, however, that while the fission-rate the death-rate and the variation in the rate of fission varied greatly at different times, owing largely to changes in temperature and variations in the culture solution, they were essentially the same in all of the groups at any given time throughout the entire experiment. This seems to show that neither conjugation nor encystment in Didinium appreciably affects the vigor of the stock or the variability in the rate of fission. It seems to prove that these processes are not rejuvenating processes, at any rate not in the sense in which Calkins has used this term: namely, that it consists in reorganization in which accumulated waste materials are eliminated.

This conclusion is, moreover, supported by the fact that toward the close of the experiment when the stock was very weak it was almost impossible to induce encystment, and by the fact that conjugation which occurred very freely in mass cultures of this weak stock produced no improvement whatever, in fact, these weakened didinia in mass cultures where conjugation occurred abundantly, died out much more freely than they did in isolation cultures where conjugation did not occur at all. If the loss of vigor in the stock is due to an accumulation of waste and if conjugation and encystment serve to eliminate this waste as Calkins maintains why was there no improvement in the weakened stock of didinia in which both of these processes occurred? And why was there no improvement if conjugation causes an increase in variation which results in improvement in adaptation to existing conditions as Jennings maintains? There seems to be no answer to the first of these questions but the second may be dealt with as follows:

Jennings assumes that the production of favorable characters is due to the union of nuclear substances which differ in potency. If, therefore, the nuclear potency of the conjugants is the same one would not, in accord with Jennings' contention, expect any favorable effect.

The didinia used in the experiments described in the preceding pages were very closely related. It may, consequently be maintained that the failure to obtain any effect by conjugation was due to the similarity of the nuclear potency of the conjugants. If this is true, it is obvious that our results do not militate against the contentions of Jennings as set forth above.

67. Some distributional problems of Okefinokee swamp. A. H. WRIGHT, Cornell University.

Many of the forms of the dry open sandy fields or pine forests of southeastern United States were absent on the Okefinokee Swamp Islands, e.g., six species of snakes and the gopher turtle. The last form suggests the swamp's influence on subterranean mammals of southeastern Georgia. Some of these in their avoidance of the swamp and in their enveloping of it often have their range limits quite abruptly marked by the swamp, e.g., three species of gophers, three short-tailed shrews, and the pine mouse. The swamp is the common source of the Atlantic coastal stream, the St. Mary's and the Gulf affluent, the Suwannee. We have no collections from the lower courses of each of these and cannot now discuss this factor. We had expected to find fixed peculiar stable races or subspecies because of the isolated nature of some of the islands but segregation has not yet placed a definite local stamp on the forms within the swamp. With the dry land forms it is a barrier but for others it is rather a melting pot for many of the supposed cardinal characters of distinction. Or it may represent the inherent variation possible in one limited geographical region, not what might occur in an extensive or expansive stretch of territory, e.g., pilot snakes with the temporal scutellation of seven supposed different forms, the overlapping of scale rows and ocular formulae of the DeKay's and red-bellied snakes, the presence of Osceola and Lamprokeltis characters in one specimen, etc., etc. Or the swamp may be interpreted as a meeting ground of two or three faunas or elements, e.g., three types of racoons, one from the north, one from Florida, and one from the west, or two bears, one the Floridan, the other the Louisianian with northern tendencies. Many of the introduced forms of the Atlantic seaboard to the immediate east, like the house mouse, black rat, roof rat and English sparrow are absent. The largest mammals of southeastern United States are there in great abundance and these carnivores may account for the scarcity of small mammals.

68. A means of transmitting the fowl nematode, Heterakis papillosa bloch. By JAMES E. ACKERT, Kansas State Agricultural College.

It has been found recently that the fowl nematode, Heterakis papillosa Bloch, may be transmitted to chickens by the feeding of dung earthworms, Helodrilus parvus (Eisen), taken from poultry yards in which the fowls were heavily infested with H. papillosa. The chickens were reared from time of hatching under controlled conditions, and feedings of H. parvus were made on three different occasions, infec-

tions of the fowls resulting each time. Other chickens kept in the same enclosure, but not fed experimentally, were free from nematodes. Whether or not these are cases of parasitism or of mere association remains to be determined.

69. Further studies on changes in Thelia bimaculata brought about by insect parasites. (Illustrated with lantern.) S. I. KORNHAUSER.

At a previous meeting of this society (Columbus, 1915), the author discussed various modifications of the Membracid, Thelia bimaculata, produced by internal insect parasites (then unidentified). The most striking change occurs in the male which, when parasitized early in its ontogeny, assumes normal female coloration. The pronotum of the male is normally dark brown with a bright orange-yellow vitta on each side; the female is gray, the vitta being only slightly visible. In parasitized males the hypodermal yellow pigment disappears from the vitta, the punctures become dark with melanic pigment, and the rest of the pronotum loses its uniform brown color; the melanin being restricted to the punctures and the greenish-yellow hypodermal pigment showing through the chitin between the punctures. Thus true female color is established by the loss of male characteristics and the gain of female characteristics. A series of stages was gotten showing the gradual disappearance of the yellow and the assumption of melanin in the vitta of various males, the degree of change depending on the state of development of the parasites in the fifth instar of Thelia previous to the final moult. No change in color takes place in parasitized females.

During the past year an abundance of material has been collected and a more complete study made of the changes in both sexes, nymphs as well as adults. The parasites have been reared and shown to be a new species of the genus Aphelopus, one of the Dryinidae. This hymenopteron lays its egg apparently in the nymph of Thelia, where it undergoes polyembryonic development passing through a complicated hypermetamorphosis. Fifty to sixty larvae result and become full-grown during the fifth instar of the host, if the egg from which they developed was deposited in a Thelia of the first or second instar. In this case the larvae emerge from holes in the ventral side of the nymph, after devouring everything within the chitin of the host. They drop to the ground, burrow and pupate. On the other hand, if the parasites are only partially developed in the fifth instar, the host becomes an adult, but modified accordingly to the degree of development of the parasites. With greater difficulty they may later emerge from the adults.

The males of Thelia possess in diploid number twenty-one chromosomes, the largest of which is the X-chromosome. The female has twenty-two chromosomes, including two large X-chromosomes. These facts were corroborated during the past summer by observations on the developing external genitalia, the size relations in the chromosomes in these soma cells being exactly those previously found in the spermatogonia and oögonia.

Nymphs of the second instar show external sex differences through the form of the segments which produce the external genitalia. These differences become more marked in the third instar, more so in the fourth, and still more in the fifth. The testes develop greatly but the ovaries remain small even until the fifth instar, although the size of the female as a whole is greater than that of the male. If the individual is parasitized early, the growth of the external genetalia is retarded in either sex; so that those of the fifth instar resemble in form and size those of the normal fourth instar. Neither sex changes toward the opposite sex nor toward a neutral form in the genitalia. The size of the abdomen does become greater in the parasitized male.

A comparative study was next made of the sizes of parasitized and normal adult Thelias. The results are given in tabular form:

	NUMBER OF INDIVIDUALS	AVERAGE LENGTH OF PRONOTUM	AVERAGE WIDTH SAME
		mm.	*mm.*
Normal males	114	11.55	4.73
Parasitized males	127	12.11	4.98
Parasitized males with changed color	98	12.24	5.03
Parasitized males no change in color	29	11.68	4.85
Normal females	111	13.39	5.41
Parasitized females	100	13.11	5.33

Thus parasitized males increase considerably, whereas parasitized females show a slight decrease in size. With the assumption of female color, males tend toward the female in size and form.

This is shown too in all other organs of the body: wing size, size, pattern and color of head; size of proboscis; size of legs; size of endosclerite; size of digestive tube; and size of abdomen, especially the terminal segments. The parasitized female is just a little undersized but normal in form, except that the ventral and terminal plates of the abdomen are soft, non-pigmented, and much like those of the fifth instar. This is the only juvenal character found in parasitized adults.

The parasites effect a reduction in size of the external genitalia of both male and female adults, but neither resembles the opposite sex. In parasitized males with normal color the genetalia may be considerably reduced in size, showing that they are very easily effected.

The changes are not directly due to the state of the primary sex organs; for, in normally colored but parasitized males, the testes may still be quite normal at the time of the final moult. This summer one unique male was found: parasitized, with female coloration; but with one testis intact, slightly undersize but with normal mitoses and spermatozoa. The changes in the secondary sexual characters are doubtlessly to be correlated with changes in nymphal metabolism. The male nymphs grow more rapidly, are smaller in size, darker in color, and are sexually mature when they become adults, the testes filling the greater part of the abdomen. The female nymphs develop more

slowly, become larger, store fat, and when they moult are prepared for the production of food for egg materials. The male is active and has a higher power of oxidation; the female is anabolic to a greater degree. The presence of parasites in the male nymph brings about lower oxidation, storing of fat, retarded rate of development, increased size; and with this change in metabolism comes a change in some of the secondary sexual characters. But changed metabolism is not powerful enough to change the external genetalia, it merely reduces them in size. These organs are laid down early in the ontogeny of the animal and are doubtlessly as old phylogenetically as the sex chromosomes, which make one male and the other female. But such secondary sexual characters as color and form, which have probably arisen later phylogenetically, through sexual selection or otherwise, are altered when a change in metabolism takes place.

70. Some experiments on the transmission of swamp fever by insects. JOHN W. SCOTT, University of Wyoming.

In 1915 the writer reported at Berkeley an experiment which appeared to prove that swamp fever in horses may be transmitted by the stable-fly, Stomoxys calcitrans.

The experiments to be mentioned here required the construction of a second screened cage large enough to hold six horses. Into Cage A three horses in good condition were kept, and two well horses were placed in Cage B. Three available diseased horses were exposed alike in the two cases; these horses were so rotated through the cages that there was always at least one diseased horse in each cage, and no horse remained longer than two successive days in either cage. Stable-flies were raised and kept in Cage A, and Cage B was kept free from flies. Two out of three of the well horses in Cage A contracted the disease, and the well horses in Cage B remained uninfested. It is believed that we have here strong circumstantial evidence that stable-flies were responsible for the infection.

In the next experiment stable-flies were taken from Cage A, confined in fruit jars with a mosquito netting cover, and exposed through the netting to the backs of two horses that were running free in a lot. Early frost in the fall of 1915 cut short this experiment after a few such exposures. However, in about two weeks one horse first gave evidence of developing the disease; the other horse gave no immediate signs of infection though some eight months later he developed a slow-going chronic case. Since we have never had a case develop as the result of horses running together in a lot with diseased horses, the experiment affords additional proof that Stomoxys calcitrans may transmit swamp fever.

In the experiments performed during the past summer, all diseased horses were kept in Cage A, and all well horses experimented with were kept in Cage B. Again stable flies were kept in Cage A, and no biting flies allowed in Cage B. One of the experiments was to determine in a rough way the smallest amount of infective blood that would

produce the disease. For this purpose a medium fine hypodermic needle was used to puncture the skin of a diseased horse, and then without drying or washing was used to puncture the skin of a horse in Cage B. This operation was repeated several times, but not more than twice on the same day. The horse used in Cage B developed the disease. This experiment shows that the amount of virus necessary to produce the disease is very small, and that a swarm of flies, as the result of interrupted feeding, could easily convey enough of the blood to produce swamp fever. In a second experiment green headed flies, Tabanus (Sp ?), were used; the interrupted feeding method was employed, first allowing the tabanids to bite diseased horses and then a well horse in Cage B. Though we could use only one horse, the result indicates that swamp fever can also be transmitted by these flies. In a third experiment stable-flies wre again used. These were exposed in small wire cages to the backs of swamp fever horses; after they had begun to feed they were transferred to the backs of two healthy horses in Cage B. One of these has apparently contracted a mild form of the disease; the other so far has shown no signs of an infection, and since he was used in an experiment in 1915 with negative results he may be immune.

A full account and discussion of the foregoing experiments will appear in a short time. It seems clear:

1. That swamp fever can be transmitted by certain biting insects such as Stomoxys calcitrans and probably Tabanus (sp ?);
2. That a mechanical transmission of infected blood in extremely small amounts is sufficient to produce the disease.
3. That the insect theory of transmission is sufficient to account for epidemics of swamp fever, accords well with the seasonal distribution of cases, and explains why the worst epidemics as a rule occur during wet seasons, when biting flies are usually most abundant;
4. That these experiments do not forbid the idea that some certain intermediate host is a still more effective means of distributing the virus.

A full explanation cannot be given until we know more about the nature and cause of the disease. It is known that swamp fever is due to one of the filterable viruses; the virus is capable of being propagated in the body of the horse, and so far has not yielded to staining or to bacteriological technique. Whether the virus is capable of self-propagation, or partakes of the nature of a cell product, a sort of pathologic hormone as it were, remains to be answered.

71. The domestic cat a host of Taenia pisiformis Bloch. By J. E. Ackert and A. A. Grant, Kansas State Agricultural College.

An attempt to infect domestic cats with the common dog tapeworm, Taenia pisiformis Bloch, has apparently succeeded. Of ten kittens, reared under controlled conditions and fed cysticerci from the viscera of cottontails, Sylvilagus floridanus mearnsii, eight kittens became infected with T. pisiformis (two to eight parasites per individual).

None of the controls (four kittens of the same litters as the experimental ones) harbored any tapeworms. The sexually mature specimens obtained are evidently young T. pisiformis, being somewhat smaller than the average adult of this species. This is another of the instances in which adult carnivore cestodes are sufficiently generalized to develop in hosts belonging to different families.

CONSTITUTION

Article I

NAME AND OBJECT

Section 1. The Society shall be called the "American Society of Zoölogists."

Sec. 2. The object of the Society shall be the association of workers in the field of Zoölogy for the presentation and discussion of new or important facts and problems in that science and for the adoption of such measures as shall tend to the advancement of zoölogical investigation in this country.

Article II

MEMBERSHIP

Section 1. Members of the Society shall be elected from persons who are active workers in the field of Zoölogy and who have contributed to the advancement of that science.

Sec. 2. Election to membership in the Society shall be upon recommendation of the Executive Committee.

Sec. 3. Each member shall pay to the Treasurer an annual assessment as determined by the Society. This assessment shall be considered due at the annual meeting and the name of any member two years in arrears for annual assessments shall be erased from the list of members of the Society, and no such person shall be restored to membership unless his arrearages shall have been paid or he shall have been re-elected.

Article III

OFFICERS

Section 1. The officers of the Society shall be a President, a Vice-President, a Secretary-Treasurer and the members at large of the Executive Committee.

Sec. 2. The Executive Committee shall consist of the President, the Vice-President, the Secretary-Treasurer and five members elected from the Society at large. Of these five members, one shall be elected each year to serve five years. If any member at large shall be elected to any other office, a member at large shall be elected at once to serve out the remainder of his term.

Sec. 3. These officers shall be elected by ballot at the annual meeting of the Society and their official terms shall commence with the close of the annual meeting, except that the Secretary-Treasurer shall be elected triennially and shall serve for three years.

Sec. 4. The officers named in Section 1 shall discharge the duties usually assigned to their respective offices.

Sec. 5. Vacancies in the board of officers, occurring from any cause, may be filled by election by ballot at any meeting of the Society. A vacancy in the Secretary-Treasuryship occurring in the interval of the meetings of the Society may be filled by appointment, until the next annual meeting, by the Executive Committee.

Sec. 6. At the annual meeting the President shall name a nominating committee of three members. This committee shall make its nominations to the Secretary not less than one month before the next annual meeting. It shall be the duty of the Secretary to mail the list of nominations to all members of the Society at least two weeks before the annual meeting. Additional nominations for any office may be made in writing to the Secretary by any five members at any time previous to balloting.

Article IV

MEETINGS OF THE SOCIETY

Section 1. Unless previously determined by the Society the time and place of the annual meeting of the Society shall be determined by its Executive Committee. Special meetings may be called and arranged for by the Executive Commitee. Notices of such meetings shall be mailed to all members of the Society at least two weeks before the date set for the meeting.

Sec. 2. Sections of the Society may be organized in any locality by not less than ten members, for the purpose of holding meetings for the presentation of scientific papers. Such sections shall have the right to elect their own officers and also associate members; provided, however, that associate membership in any section shall not confer membership in the Society.

Article V

QUORUM

Twenty-five members shall constitute a quorum of the Society and four a quorum of its Executive Committee.

Article VI

CHANGES IN THE CONSTITUTION

Amendments to this Constitution may be adopted at any meeting of the Society by a two-thirds vote of the members present, upon the following conditions:

(a) The proposed amendment must be in writing and signed by at least five members of the Society.

(b) This signed proposal must be in the hands of the Secretary at least one month before the meeting of the Society at which it is to be considered.

(c) The Secretary shall mail copies of the proposed amendment to the members of the Society at least two weeks before the meeting.

BY-LAWS

DUES

(1) The annual dues for members, unless remitted or changed by the vote of the Society, shall be seven dollars.

SECRETARY-TREASURER

(2) The duties and privileges of the Secretary-Treasurer shall be as follows:

(a) He shall keep the records and be in charge of the funds of the Society.

(b) At the annual business meeting he shall present a statement to date of the funds of the Society.

(c) Whenever the proper officers of a number of related societies shall have a conference with a view to determining a common time and place for the several annual meetings, he shall act as the delegate or representative of this Society. (See also 4-a.)

(d) He shall employ a typewriter or printer whenever in his judgment such employment will expedite the business of the Society, and

(e) He shall be reimbursed out of the funds of the Society for expenses incurred in attending meetings of the Society.

AUDITING COMMITTEE

(3) The President shall annually appoint an auditing committee of two, who shall audit and report upon the financial record and statement of the Secretary-Treasurer at the meeting for which they were appointed.

AFFILIATION WITH THE AMERICAN SOCIETY OF NATURALISTS

(4) Affiliation with the American Society of Naturalists is provided for as follows:

(a) It shall be the policy of the Society to hold its annual meetings in conjunction with the American Society of Naturalists, whenever satisfactory arrangements to do so can be made; and, with this in view, before the time and place for an annual meeting shall have been determined by the Executive Committee, the Secretary-Treasurer shall ascertain from the Secretary of the American Society of Naturalists the time and place for holding the annual meeting of that Society. It shall be the policy of the Society, however, to hold meetings in both Eastern and Central-Western territory, and the distribution of the meetings between the two territories shall be determined in general on the basis of the representation of Eastern and Western members in the Society. (See also 2-c.)

PROGRAM RULES

(5) In matters relating to programs for annual meetings the following rules shall be observed:

(a) Papers shall be listed and presented according to subject matter in the following groups: 1. Comparative Anatomy; 2. Embryology; 3. Cytology; 4.

Genetics; 5. Comparative and General Physiology; 6. Ecology, and 7. Miscellaneous, or other groups at the discretion of the Secretary-Treasurer.

(b) Whenever conditions require it the Executive Committee shall schedule two or more groups for the same hour and rearrange the program to bring together papers on subjects of more general interest for meetings of the whole Society. The Committee, however, is instructed to avoid conflicts as much as possible.

(c) Papers shall be listed in their respective groups in the order received. When a member offers more than one paper those following the one designated first shall be placed at the end of the list and shall not be read until all first papers by members shall have been twice called for.

(d) All papers not read when called for as listed shall be placed at the end of the group list, and, if not read when called for the second time, they shall be read by title only.

(e) The titles of "introduced" papers shall be listed in the groups after the titles of papers to be read by members. Such papers shall be read by title only in case the entire program cannot be completed during four regular sessions for reading papers.

(f) Fifteen minutes shall be the maximum time allowed for the presentation of a paper.

(g) Each title sent in for the program must be accompanied by a typewritten abstract of the paper for publication and distribution to members of the Society before the meeting.

HISTORICAL REVIEW

The American Society of Zoölogists, as now organized, is directly descended from the American Morphological Society, the Central Naturalists, the Zoölogical Society of America, and the Eastern and Central Branches of the American Society of Zoölogists. A brief review of the history of these societies is, therefore, of considerable interest.

The material for this account is taken in part from the preface to the List of Members of the American Society of Zoölogists issued in 1906.

American Morphological Society

During the year 1890 the following circular, which resulted in the formation of the American Morphological Society, was issued:

October 16, 1890.

Dear Sir—During the last ten years there has been a very noticeable increase in the number of persons in this country who are devoting themselves to the study of animal morphology. With the increased enthusiasm which has arisen for such studies, and with the increased facilities for their prosecution which we now possess, it seems probable that the near future will witness in America a remarkable addition to the ranks of the investigators of animal morphology.

The vast extent of territory over which our students are and will be scattered renders it difficult for many to keep in touch with the scientific advances which are being made in distant parts of the country, a necessary condition for effi-

cient and profitable work, where specialization is an inevitable concomitant of successful investigation.

It has been considered advisable that some means should be devised whereby this scientific isolation, felt by most investigators, should be broken up, and it is proposed to form in connection and affiliation with the American Society of Naturalists an Association of Morphologists, which shall hold stated meetings during the Christmas vacation, at which special and general morphological problems may be brought forward and discussed.

The time of year chosen is one that recommends itself to most investigators as interfering least with their private and collegiate work, and it has been thought well for the Association to avail itself of the many advantages resulting from a connection with the American Society of Naturalists.

The undersigned, therefore, call a meeting of those interested in the formation of an Association of American Morphologists, to be held in Boston (the details of the meeting to be announced later) on Monday, December 29, 1890, and respectfully request your coöperation.

If the formation of such a Society meets with your approval, and you desire to assist in its formation, please notify Dr. J. Playfair McMurrich, Clark University, Worcester, Mass., to that effect, in order that notices of further arrangements for the meetings may be sent to you.

(Signed) C. O. Whitman,
Henry F. Osborn,
E. B. Wilson,
Edward G. Gardiner,
J. Playfair McMurrich.

The first meeting was held December 29, 1890, at the Massachusetts Institute of Technology, Dr. E. G. Gardiner being called to the chair and Dr. J. Playfair McMurrich acting as Secretary. Organization followed, after which Dr. E. B. Wilson was elected Chairman and Dr. J. Playfair McMurrich Secretary-Treasurer for the meeting.

The original members with their addresses at the time of this meeting, are given in the following list:

(The list is copied from the minutes of the first meeting.)

Ayers, Howard, Ph.D., The Lake Laboratory, Milwaukee, Wis.
Andrews, E. A., Ph.D., Johns Hopkins University, Baltimore, Md.
Baur, G., Ph.D., Clark University, Worcester, Mass.
Bumpus, H. C.. Ph.B., Brown University, Providence, R. I.
Clarke, S. F., Ph.D., Williams College, Williamstown, Mass.
Cope, E. D., 2102 Pine Street, Philadelphia, Pa.
Gardiner, E. G., Ph.D., Mass. Inst. of Technology, Boston, Mass.
Hyatt, Alpheus, Boston Society of Natural History, Boston, Mass.
Mall, F. P., M.D., Clark University, Worcester, Mass.
Mark, E. L., Ph.D., Harvard College, Cambridge, Mass.
McMurrich, J. P., Ph.D., Clark University, Worcester, Mass.
Minot, C. S., D.Sc., Harvard Medical School, Boston, Mass.
Morse, E. S., Ph.D., Peabody Academy of Science, Salem, Mass.

MORGAN, T. H., Ph.D., Johns Hopkins University, Baltimore, Md.
OSBORN, H. F., D.Sc., Princeton College, Princeton, N. J.
PARKER, G. H., B.Sc., Harvard College, Cambridge, Mass.
RANKIN, W. M., Ph.D., Princeton College, Princeton, N. J.
SCOTT, W. B., Ph.D., Princeton College, Princeton, N. J.
SCUDDER, S. H., Cambridge, Mass.
SMITH, S. I., Ph.D., Yale University, New Haven, Conn.
WATASE, S., Ph.D., Clark University, Worcester, Mass.
WHEELER, W. M., Clark University, Worcester, Mass.
WHITMAN, C. O., Ph.D., Clark University, Worcester, Mass.
WILSON, E. B., Ph.D., Bryn Mawr College, Bryn Mawr, Pa.
WILSON, H. V., Ph.D., United States Fish Commission, Woods Hole, Mass.
WRIGHT, R. R., B.Sc., University of Toronto, Canada.

CENTRAL NATURALISTS

The Central Naturalists first met in response to the following call:

CHICAGO, December 8, 1899.

DEAR SIR—The desirability of forming a Western branch of the American Society of Naturalists, with the same objects and conditions of membership as the main society, has long been under consideration by the Naturalists of the Central and Western States.

For the purpose of starting such a branch if it seems, on discussion, desirable (the main society acquiescing), this call is issued for a meeting of members of the American Society of Naturalists and affiliated scientific societies living west of the Alleghanies and of others interested in providing for an annual meeting of the Western Naturalists; the present meeting to be held at the Hull Biological Laboratories, University of Chicago, Thursday and Friday, December 28 and 29, 1899.

The provisional program is as follows:

Thursday, 10 a.m.—General meeting in Room 23, Botany Building, for organization and reading of papers. 1–2 p.m., Luncheon at Quadrangle Club. 3 p.m., Discussion: Methods and Results of Limnological Work. 6.30 p.m., Dinner at the Quadrangle Club.

Friday, 9 a.m.—General meeting for reading of papers.

You are respectfully invited to be present at the meeting. Titles of papers to be read should be sent to C. B. Davenport, 5725 Monroe avenue, Chicago, so as to reach him before December 16, at which time a second circular will be sent out. A few persons can probably be accommodated in the dormitories of the University without charge. Such rooms will be assigned to earliest applicants. Please reply to this letter before December 15.

C. R. BARNES,
H. H. DONALDSON,
S. A. FORBES,
WILLIAM A. LOCY.
JACOB REIGHARD.

(Among other Naturalists who have signified their approval of this call are: Prof. C. L. Edwards, University of Cincinnati; Prof. Carl Eigenmann, University of Indiana; Dr. H. S. Jennings, University of Michigan; Prof. H. V. Neal, Knox College, Illinois; Dr. W. S. Nickerson, University of Minnesota; Prof. C. P. Sigerfoos, University of Minnesota; Prof. H. B. Ward, University of Nebraska, and Prof. C. O. Whitman, University of Chicago.)

The following year a notice was issued as follows:

CHICAGO, ILL., November 15, 1900.

DEAR SIR—The meeting of Naturalists of the Central and Western States at Chicago last year (see *Science* for February 16, 1900) was so successful that a second meeting will be held at the Hull Biological Laboratories, University of Chicago, Thursday and Friday, December 27 and 28, 1900. It is expected that a permanent organization will be effected at this meeting.

The provisional program is as follows:

Thursday, 10 a.m.—General meeting in Room 24, Zoölogical Building (furnished with a projecting lantern), for organization and reading of the more general papers. 1 to 2 p.m., Luncheon at the Quadrangle Club. 3 p.m., Discussion: State Natural History Surveys; Methods, results, coöperation. 6.30 p.m., Dinner at the Quadrangle Club.

Friday, 8 a.m.—General meeting for reading of papers. At this time at least two sections, one in Zoölogy and one in Botany, will be formed, at which the more special papers will be read.

You are respectfully invited to be present at the meeting and to bring your advanced students. Titles of papers to be read should be sent to C. B. Davenport, 5725 Monroe Avenue, Chicago, or to C. R. Barnes, University of Chicago. A second circular will be sent to all who attended last year's meeting and to those who request it in reply to this letter before December 14.

* * * * * * * * *

Committee on Meeting:
E. A. BIRGE, *Chairman*,
C. R. BARNES,
T. G. LEE,
C. C. NUTTING,
C. B. DAVENPORT, *Secretary*.

The attendance at the second meeting exceeded 100 and it became necessary to hold two sections, a zoölogical and a botanical. This division paved the way for the formation, the following year, of a distinct zoölogical society.

ZOÖLOGICAL SOCIETY OF AMERICA

In December, 1901, the Eastern and Central Naturalists met together at Chicago and all the Zoölogists met with the American Morphological Society. In accordance with a desire that had been expressed among the "Central Naturalists," the Zoölogists and Botanists of that body met separately during one of the days and organized. The Zoölogists met at Kent Theatre, University of Chicago, on January 1, 1902, in response to a call. Dr. C. B. Davenport was

chosen to preside. A committee of three, consisting of Professors Reighard, Eigenmann and Davenport, was appointed to draft a constitution to be acted on at the next meeting and the body then adjourned to meet in Washington the following year. At a meeting of the Committee on Organization a constitution was drawn up, the name "Zoölogical Society of America" being selected.

Central and Eastern Branches of the American Society of Zoölogists

In Convocation week, 1902–03, the Zoölogists of the Central and Western States met in Washington with their Eastern brethren. At this time they adopted the constitution drawn up by the joint constitutional committee appointed at the joint Washington meeting. By this and further appropriate action they organized as the Central Branch of the American Society of Zoölogists, the American Morphological Society becoming at the same time the Eastern Branch of the same society.

American Society of Zoölogists

The present organization of the American Society of Zoölogists, effected at a joint meeting of the Eastern and Central Branches of the Society at Philadelphia in 1913, grew out of a general feeling of dissatisfaction with provisions of the constitution relating to the holding of joint meetings of the two Branches and the election of members.

At the annual meeting of the Eastern Branch of the Society in Ithaca in 1910 the Executive Committee was instructed to consider the advisability of changes in the constitution with reference to these matters. The following quotation is taken from the report of this Committee to the Society at a joint meeting held at Princeton in 1911:

"At the Ithaca meeting of the Society it was voted that the Executive Committee be instructed to consider the advisability of changes in the constitution with reference to the place of meeting and the election of members. Acting under these instructions your Committee has carefully considered the points raised in the motion quoted and certain related matters as well. Our conclusions are as follows:

"1. That the arrangements at present existing between the Eastern and Central Branches of the Society in respect to (a) the holding of joint meetings, (b) the election of members, and (c) other minor administrative matters, have not been found to be satisfactory in practical operation. The feeling of dissatisfaction regarding existing conditions is not confined to the membership of either Branch, but is general throughout the Society. On this account steps should be taken at once to bring about, if possible, a more satisfactory scheme of organization and administration of the Society.

"2. That, in the opinion of the Committee, there are essentially but two general plans of action which offer any hope of a practical solution of the difficulties. These are:

"(a) The plan of *amalgamation* of the Branches into one single unitary organization. This would mean the abolition of Eastern and Central Branches as such, the election of a single set of officers for the Society as a whole, and the holding of but one meeting annually. The place and time of this meeting could

be decided by the Executive Committee each year independently on the basis of the merits of the whole situation as it appears at the time. Should this plan be adopted, however, it would, in our judgment, be absolutely essential that some provision be made whereby the holding of a fair proportion of the meetings of the Society in central territory would be assured.

"(b) The plan of *separation* of the Branches into two distinct and independent societies, each having its own officers, and meeting whenever and wherever it pleased. Should such a plan prevail, however, it would appear to be highly desirable that nothing should be put into the constitution or by-laws of either society which would in any way hinder or prevent the holding of a joint meeting of the two societies, whenever such course seemed desirable.

"Feeling that the problem before us is one of great importance, upon a wise and just solution of which the future welfare and dignity of the Society must in some measure depend, your Committee would recommend:

"1. The appointment at this meeting of a Committee on Organization and Policy to consist of three members of the Eastern Branch and three members of the Central Branch and the President of the Society *ex officio*, to consider during the ensuing year the problem of the organization of the Society and to prepare a new constitution and a set of by-laws."

The Committee on Organization and Policy, appointed at the Princeton meeting, is as follows:

E. G. Conklin,
G. A. Drew,
R. G. Harrison,
} Representing the Eastern Branch.

F. R. Lillie,
M. M. Metcalf,
W. A. Locy,
} Representing the Central Branch.

This Committee made no report at the joint meeting held at Cleveland in 1912, but during the summer of 1913 a meeting of the Committee, called by the president of the Society, H. B. Ward, was held at Woods Hole, at which a constitution for the Society was outlined. At this meeting the absent members, H. V. Wilson, M. M. Metcalf and W. A. Locy, were represented by G. H. Parker, George Lefevre and Jacob Reighard. The draft of the constitution formulated at this meeting was later submitted by the chairman of the Committee, G. A. Drew, to all members of the original committee, and the constitution finally agreed upon is practically the same as that adopted by the Society at the joint meeting held at Philadelphia in 1913 (see page 71).

LIST OF FORMER OFFICERS

American Morphological Society

President	*Vice-President*	*Secretary-Treasurer*
1890—E. B. Wilson	.....	J. P. McMurrich
1891—C. O. Whitman	E. L. Mark	J. P. McMurrich
1892—C. O. Whitman	H. F. Osborn	J. P. McMurrich

President	*Vice-President*	*Secretary-Treasurer*
1893—C. O. Whitman	E. B. Wilson	J. P. McMurrich
1894—C. O. Whitman	W. B. Scott	G. H. Parker
1895—E. B. Wilson	W. B. Scott	G. H. Parker
1896—E. L. Mark	H. F. Osborn	G. H. Parker
1897—C. S. Minot	S. I. Smith	G. H. Parker
1898—H. F. Osborn	T. H. Morgan	G. H. Parker
1899—E. G. Conklin	W. M. Wheeler	Bashford Dean
1900—T. H. Morgan	H. C. Bumpus	J. M. Kingsley
1901—J. S. Kingsley	E. A. Andrews	T. H. Montgomery
1902—H. C. Bumpus	G. H. Parker	M. M. Metcalf

Additional Members of the Executive Committee

1891—E. B. Wilson	1897—J. S. Kingsley
H. F. Osborn	Bashford Dean
1892—E. L. Mark	1898—C. B. Davenport
T. H. Morgan	F. R. Lillie
1893—T. H. Morgan	1899—J. P. McMurrich
C. B. Davenport	G. H. Parker
1894—E. A. Andrews	1900—F. R. Lillie
F. H. Herrick	Jacob Reighard
1895—T. H. Morgan	1901—C. F. W. McClure
S. Watase	C. W. Hargitt
1896—E. G. Conklin	1902—H. S. Jennings
William Patten	R. G. Harrison

AMERICAN SOCIETY OF ZOÖLOGISTS

EASTERN BRANCH	*President*	CENTRAL BRANCH
G. H. Parker	1903	Jacob Reighard
E. A. Andrews	1904	C. H. Eigenmann
W. E. Castle	1905	F. R. Lillie
W. E. Castle	1906	C. C. Nutting
C. B. Davenport	1907	S. A. Forbes
W. M. Wheeler	1908	E. A. Birge
H. S. Jennings	1909	E. A. Birge
T. H. Montgomery	1910	C. E. McClung
H. V. Wilson	1911	George Lefevre
A. G. Mayer	1912	H. B. Ward
Raymond Pearl	1913	H. B. Ward
Jacob Reighard	1903	H. F. Nachtrieb
W. E. Castle	1904	S. J. Holmes
William Patten	1905	William A. Locy
William Patten	1906	George Lefevre
F. H. Herrick	1907	H. B. Ward
H. S. Jennings	1908	M. F. Guyer
H. V. Wilson	1909	M. F. Guyer

EASTERN BRANCH	*Vice-President*	CENTRAL BRANCH
H. H. Wilder	1910	H. F. Nachtrieb
H. E. Crampton	1911	R. H. Walcott
G. A. Drew	1912	C. M. Child
Alex. Petrunkevitch	1913	C. M. Child

Secretary-Treasurer

G. A. Drew	1903	Frank Smith
G. A. Drew	1904	F. R. Lillie
H. S. Pratt	1905	C. E. McClung
H. S. Pratt	1906	T. G. Lee
C. J. Herrick	1907	T. G. Lee
L. L. Woodruff	1908	T. G. Lee
L. L. Woodruff	1909	Charles Zeleny
H. W. Rand	1910	H. V. Neal
Raymond Pearl	1911	H. V. Neal
J. H. Gerould	1912	W. C. Curtis
Caswell Grave	1913	W. C. Curtis

Executive Committeemen

EASTERN BRANCH	CENTRAL BRANCH
F. R. Lillie	George Lefevre
T. H. Montgomery	T. G. Lee
H. C. Bumpus	Herbert Osborn
H. S. Jennings	C. H. Eigenmann
E. A. Andrews	J. G. Needham
W. R. Coe	S. J. Holmes
G. A. Drew	W. A. Locy
M. M. Metcalf	C. M. Child
D. H. Tennent	R. H. Walcott
R. G. Harrison	W. C. Curtis
H. E. Jordan	Oscar Riddle
C. E. McClung	H. B. Ward
	Chauncey Juday
	H. W. Norris
	C. E. McCluug
	H. F. Nachtrieb

AMERICAN SOCIETY OF ZOÖLOGISTS (AMALGAMATED)

	President	*Vice-President*	*Executive Committeemen*
1914.	C. E. McClung	M. F. Guyer	H. E. Jordan
1915.	W. A. Locy	W. E. Ritter	H. F. Nachtrieb
1916.	D. H. Tennent	Charles Zeleny	H. V. Wilson

LIST OF PLACES OF MEETING

American Morphological Society

1890—Boston
1891—Philadelphia
1892—Princeton
1893—New Haven
1894—Baltimore
1895—Philadelphia
1896—Boston
1897—Ithaca
1898—New York
1899—New Haven
1900—Baltimore
1901—Chicago
1902—Washington

Central Naturalists

1899—Chicago
1900—Chicago

Society of American Zoölogists

1901—Chicago
1902—Washington

American Society of Zoölogists

EASTERN BRANCH	JOINT MEETINGS	CENTRAL BRANCH
1903—Philadelphia	1905—Ann Arbor	1903—St. Louis
1904—Philadelphia	1908—Baltimore	1905—(Mch.) Chicago
1906—New York	1911—Princeton	1907—(Mch.) Madison
1907—New Haven	1912—Cleveland	1907—Chicago
1909—Boston	1913—Philadelphia	1910—(Apr.) Iowa City
1910—Ithaca		1910—Minneapolis
		1912—(Apr.) Urbana

American Society of Zoölogists (Amalgamated)

1914. Philadelphia
1915. Columbus
1916. New York

AMERICAN SOCIETY OF ZOÖLOGISTS

OFFICERS AND LIST OF MEMBERS OF THE SOCIETY

Officers

President.....MAYNARD MAYO METCALF
Vice-President.....CHARLES ZELENY
Secretary-Treasurer.....CASWELL GRAVE

Executive Committee

GEORGE LEFEVRE — L. J. COLE
A. F. SHULL — R. P. BIGELOW
H. V. WILSON

HONORARY MEMBER

James Viscount Bryce, Hindleap, Forest Row, Sussex, England.

MEMBERS

ABBOTT, JAMES FRANCIS, A.B., A.M. (Leland Stanford), Ph.D. (Chicago), Professor of Zoölogy, *Washington University, St. Louis, Mo.*

ACKERT, JAMES EDWARD, A.B., A.M., Ph.D. (University of Illinois), Assistant Professor of Zoölogy, *Kansas State Agricultural College, Manhattan, Kan.*

ALLEE, WARDER CLYDE, S.B. (Earlham College), S.M. (Chicago), Ph.D. (Chicago), Professor of Biology, *Lake Forest College, Lake Forest, Ill.*

ALLEN, BENNET MILLS, Ph.B. (De Pauw), Ph.D. (Chicago), Professor of Zoölogy, *University of Kansas, Lawrence, Kan.*

ALLEN, EZRA, A.M., Ph.D. (University of Pennsylvania), Professor of Biology, *Philadelphia School of Pedagogy, 12th above Spring Garden, Philadelphia, Pa.*

ANDREWS, ETHAN ALLEN, Ph.B. (Yale), Ph.D. (Johns Hopkins), Life Member. Professor of Zoölogy, *Johns Hopkins University, Baltimore, Md.*

AREY, LESLIE BRAINERD, Ph.D. (Harvard), Instructor in Anatomy, *Northwestern University Medical School, 2431 Dearborn Street, Chicago, Ill.*

BAITSELL, GEORGE ALFRED, B.S. (Central College, Iowa), M.A., Ph.D. (Yale), Instructor in Biology in Yale University, *Osborn Zoölogical Laboratory, Yale Station, New Haven, Conn.*

BANTA, ARTHUR MANGUN, A.B., A.M. (Indiana), Ph. D. (Harvard), Resident Investigator, *Station for Experimental Evolution, Carnegie Institution, Cold Spring Harbor, Long Island, N. Y.*

BARDEEN, CHARLES RUSSELL, A.B. (Harvard), M.D. (Johns Hopkins), Professor of Anatomy and Dean of the College of Medicine, *University of Wisconsin, Madison, Wis.*

BARKER, FRANKLIN D., A.B., A.M. (Ottawa University, Kansas), Ph D (Nebraska), Professor of Medical Zoölogy and Parasitology, *University of Nebraska, Station A, Lincoln, Neb.*

BARROWS, WILLIAM MARTIN, B.S. (Michigan Agricultural College), S.B., S M. (in Biology) (Harvard), *371 Harvard Street, Cambridge, Mass.*

BARTELMEZ, GEORGE W., Ph.D. (Chicago), Assistant Professor of Anatomy, *University of Chicago, Chicago, Ill.*

BASSET, GARDNER CHENEY, Ph.D. (Johns Hopkins), *University of Pittsburgh, Pittsburgh, Pa.*

BAUMGARTNER, WILLIAM JACOB, A.B., A.M. (Kansas), Associate Professor of Zoölogy, *University of Kansas, 1209 Ohio Street, Lawrence, Kan.*

BECKWITH, CORA JIPSON, B.S. (Michigan), M.A., Ph.D. (Columbia), Associate Professor of Zoölogy, *Vassar College, Poughkeepsie, N. Y.*

BIGELOW, MAURICE ALPHEUS, B.S. (Ohio Wesleyan), M.S. (Northwestern), Ph.D. (Harvard), Professor of Biology, *Teachers' College, 525 West 120th Street, New York City.*

BIGELOW, ROBERT PAYNE, S.B. (Harvard), Ph.D. (Johns Hopkins), Associate Professor of Zoölogy and Parasitology, *Massachusetts Institute of Technology, Cambridge, Mass.*

BINFORD, RAYMOND, B.S. (Earlham), S.M. (Chicago), Ph.D. (Johns Hopkins), Professor of Zoölogy at Earlham College, *Earlham College, Richmond, Ind., Earlham P. O.*

BLACKMAN, MAULSBY WILLETT, A.B., A.M. (Kansas), Ph.D. (Harvard), Professor of Forest Entomology and Head of Department of Forest Zoölogy, *New York State College of Forestry, at Syracuse University, 216 Stratford Street, Syracuse, N. Y.*

BORING, ALICE MIDDLETON, A.B., A.M., Ph.D. (Bryn Mawr), Associate Professor of Zoölogy, *University of Maine, Orono, Maine.*

BRUNER, HENRY LANE, A.B. (Abingdon), Ph.D. (Freiburg), Professor of Biology, *Butler College, 324 South Ritter Avenue, Indianapolis, Ind.*

BUDINGTON, ROBERT ALLYN, B.A., M.A. (Williams), Professor of Zoölogy, *Oberlin College, Oberlin, Ohio.*

BUMPUS, HERMON CAREY, Ph.D., LL.D. (Clark), Ph.B., D.Sc. (Brown), D.Sc. (Tufts) President of Tufts College, *Tufts College, Mass.*

BURROWS, MONTROSE T., A.B. (Kansas), M.D. (Johns Hopkins), Acting Resident Pathologist, *Johns Hopkins Hospital, Baltimore, Md.*

BYRNES, ESTHER F., Ph.D.,
193 Jefferson Avenue, Brooklyn, N. Y.

CALKINS, GARY N., B.S. (Mass. Inst. Tech.), Ph.D., (Columbia) Professor of Protozoölogy, *Columbia University, New York City.*

CALVERT, PHILIP POWELL, Ph.D. (Pennsylvania), Professor of Zoölogy, *University of Pennsylvania, Zoölogical Laboratory, Philadelphia, Pa.*

CAROTHERS, E. ELEANOR, A.B., A.M., Ph.D., *Zoölogical Building, University of Pennsylvania, Philadelphia, Pa.*

CARPENTER, FREDERIC WALTON, B.S. (New York Univ.), A.M., Ph.D., (Harvard), Professor of Biology, *Trinity College, Hartford, Conn.*

CARY, LEWIS R., B.S., M.S. (Maine), M.A., Ph.D. (Princeton), Asst. Prof. of Biology, *Princeton University, Princeton, N. J.*

Casteel, Dana Brackenridge, A.B. (Allegheny), A.M. (Ohio Wesleyan), Ph.D. (University of Pennsylvania), Associate Professor of Zoölogy, *University of Texas, Austin, Texas.*

Castle, William E., A.B. (Denison), A.M., Ph.D. (Harvard), Professor of Zoölogy in *Harvard University, Payson Road, Belmont, Mass.*

Chamberlin, Ralph V., B.S. (Utah), Ph.D. (Cornell), Curator of Arachnida, Myriopoda and Annelida, Mus. Comp. Zoölogy, *Harvard University, Museum Comp. Zoölogy, Cambridge, Mass.*

Chambers, Robert, Jr., A.M. (Queen's Univ., Can.), Ph.D. (Munich), Instructor in Anatomy, *Cornell Medical College, 28th Street and First Avenue, New York City.*

Chester, Wayland Morgan, A.B., A.M., (Colgate Univ.), Professor of Biology, *Colgate University, Hamilton, N. Y.*

Child, Charles Manning, Ph.B., M.S. (Wesleyan), Ph.D. (Leipzig), Associate Professor of Zoölogy, *Hull Zoölogical Laboratory, University of Chicago, Chicago, Ill.*

Churchill, Edward Perry, A.B. (Iowa), Ph.D. (Johns Hopkins), Assistant U. S. Bureau of Fisheries, *317 Marshall Street, Hampton, Va.*

Clapp, Cornelia Maria, Ph.B. (Syracuse), Ph.D. (Chicago), Professor of Zoölogy, *Mount Holyoke College, South Hadley, Mass.*

Clark, Howard Walton, A.B., A.M. (Indiana), Scientific Assistant United States Bureau of Fisheries, *United States Biological Station, Fairport, Iowa.*

Coe, Wesley R., Ph.D. (Yale), Professor of Biology, *Yale University, New Haven, Conn.*

Coghill, George E., A.B., Ph.D. (Brown), Professor of Anatomy, *University of Kansas, R. F. D. 9, Lawrence, Kan.*

Cole, Leon J., A.B. (Michigan), Ph.D. (Harvard), Professor of Experimental Breeding, *College of Agriculture, University of Wisconsin, Madison, Wis.*

Colton, Harold Sellers, B.S., M.A., Ph.D. (Pennsylvania), Assistant in Zoölogy, *University of Pennsylvania), Philadelphia, Pa.*

Congdon, Edgar Davidson, A.B., A.M. (Syracuse), Ph.D. (Harvard), *Leland Stanford Jr. University, 330 Coleridge Avenue, Palo Alto, Cal.*

Conklin, Edwin Grant, B.S., A.B., A.M., Sc.D. (Hon.) (Ohio Wesleyan), Ph.D. (Johns Hopkins), Sc.D. (Hon.) (Pennsylvania), Professor of Biology, *Princeton University, Princeton, N. J.*

Cook, Margaret Harris, B.S., Ph.D. (Pennsylvania), *122 West Linn Street, Bellefonte, Pa.*

Copeland, Manton, S.B., S.M., Ph.D. (Harvard), Professor of Biology, *Bowdoin College, Brunswick, Maine.*

Cort, William Walter, A.B. (Colorado College), M.A., Ph.D. (University of Illinois), Assistant Professor of Zoölogy, University of California, *Department of Zoölogy, University of California, Berkeley, Calif.*

Cowles, R. P., B.A. (Stanford), Ph.D. (Johns Hopkins), Professor of Zoölogy, *University of the Philippines, Manila, Philippine Islands.*

Crampton, Guy Chester, B.A., (Princeton) M.A. (Cornell), Ph.D. (Univ. of Berlin), Associate Professor of Entomology, *Massachusetts Agricultural College, Care of Department of Entomology, Amherst, Mass.*

CRAMPTON, HENRY EDWARD, A.B., Ph.D. (Columbia), Professor of Zoölogy, *Barnard College, Columbia University;* Curator of Invertebrate Zoölogy, *American Museum of Natural History, New York City.*

CROZIER, WILLIAM JOHN, B.S. (College of the City of New York), A.M., Ph.D. (Harvard). Resident Naturalist, Bermuda Biological Station for Research; Sheldon Fellow, Harvard University. *Agar's Island, Bermuda.*

CURTIS, MAYNIE ROSE, A.B., A.M. Ph.D. (Michigan), Assistant Biologist, *Maine Agricultural Experiment Station, Orono, Maine.*

CURTIS, WINTERTON CONWAY, A.B., A.M. (Williams), Ph.D. (Johns Hopkins), Professor of Zoölogy, *University of Missouri, 208 Hicks Avenue, Columbia, Mo.*

DAHLGREN, ULRIC, A.B., M.S. (Princeton), Professor of Biology, *Princeton University, 204 Guyot Hall, Princeton, N. J.*

DANIEL, J(OHN) F(RANKLIN), S.B. (University of Chicago), Ph.D. (Johns Hopkins), Assistant Professor of Zoölogy, *University of California, 1421 Hawthorn Terrace, Berkeley, Cal.*

DAVENPORT, CHARLES BENEDICT, Ph.D. (Harvard), Director of Department of Experimental Evolution, *Carnegie Institution of Washington, Cold Spring Harbor, Long Island, N. Y.*

DAVENPORT, GERTRUDE CROTTY, B.S. (University of Kansas), *Cold Spring Harbor, Long Island, N. Y.*

DAVIS, HERBERT SPENCER, Ph.B. (Wesleyan), Ph.D. (Harvard), Professor of Zoölogy, *University of Florida, Gainesville, Fla.*

DAY, EDWARD CARROLL, A.B. (Hamilton), A.M., Ph.D. (Harvard), *Dalton Hall, Bryn Mawr College, Bryn Mawr, Pa.*

DEAN, BASHFORD, A.B. (College of City of New York), A.M., Ph.D. (Columbia), Life Member, Professor of Vertebrate Zoölogy, Columbia University; Curator of Fishes and Reptiles, *American Museum Natural History, Riverdale-on-Hudson, New York.*

DETLEFSEN, JOHN A., A.B. (Dartmouth), A.M., Sc.D. (Harvard), Assistant Professor of Genetics, University of Illinois, College of Agriculture, *916 West Nevada Avenue, Urbana, Ill.*

DODDS, GIDEON S., B.A., M.A. (Colorado), Ph.D. (Pennsylvania), Assistant Professor of Zoölogy, *University of Missouri, Columbia, Mo.*

DOLLEY, JR., WILLIAM LEE, A.B., A.M. (Randolph-Macon), Ph.D. (Johns Hopkins), Professor of Biology, *Randolph-Macon College, Ashland, Va.*

DREW, GILMAN A., Ph.D. (Johns Hopkins), Assistant Director, *Marine Biological Laboratory, Woods Hole, Mass.*

EDMONDSON, CHARLES HOWARD, Ph.B., M.S., Ph.D. (Iowa University), Assistant Professor of Zoölogy, *University of Oregon, Eugene, Ore.*

EDWARDS, CHARLES LINCOLN, B.S. (Lombard and Indiana), A.M. (Indiana), Ph.D. (University of Leipzig), Director, Dept. Nature Study, Los Angeles City Schools, *1032 West 39th Place, Los Angeles, Cal.*

EIGENMANN, CARL, H., Ph.D., A.M., A.B. (Indiana), Professor of Zoölogy; Dean of the Graduate School, *Indiana University, Bloomington, Indiana.*

ELROD, MORTON JOHN, B.A., M.A., M.S. (Simpson), Ph.D. (Ill. Wes. Univ.), Professor of Biology, *University of Montana, Missoula, Mont.*

ENDERS, HOWARD EDWIN, B.S. (Lebanon Valley College), M.S., B.S. (Michigan), Ph.D. (Johns Hopkins University), Associate Professor of Zoölogy and in charge of Biology, Purdue University, Summer School Staff, Dept. Zoölogy, Indiana University, *107 Fowler Avenue, West Lafayette, Ind.*

ERDMANN, RHODA, Ph.D. (Munich), Lecturer in Biology, Yale University and Associate, Rockefeller Institute; *Yale University, New Haven, Conn.*

EYCLESHYMER, ALBERT C., B.S. (Michigan), Ph.D. (Chicago), M.D. (St. Louis), Professor and Head of Dept. of Anatomy, University of Illinois; *University of Illinois Medical College, Honore and Congress Streets, Chicago, Ill.*

FASTEN, NATHAN, B.S. (College of City of New York), Ph.D. (Wisconsin), Instructor of Zoölogy, *Science Hall, University of Washington, Seattle, Wash.*

FERRIS, HARRY BURR, B.A., M.D. (Yale), E. K. Hunt, Professor of Anatomy, Medical Department, Yale University, *395 St. Ronan, New Haven, Conn.*

FOOT, KATHARINE, *955 Park Avenue, New York City.*

FOX, HENRY, B.S., M.A., Ph.D. (Pennsylvania), Entomological Laboratory, *Clarkesville, Tenn.*

GAGE, SIMON HENRY, B.S. (Cornell), Emeritus Professor of Histology and Embryology, Cornell University, *4 South Avenue, Ithaca, N. Y.*

GALLOWAY, THOMAS W., A.B., A.M., Ph.D. (Cumberland), A.M. (Harvard), Litt. D. (Missouri Valley) Professor Biology, *Beloit College, Beloit, Wis.*

GARMAN, HARRISON, Head of Division of Entomology and Botany, Kentucky Agricultural Experiment Station; State Entomologist, *Lexington, Ky.*

GEE, WILSON, B.S. (University of S. C.), Ph.D. (University of California), Professor of Biology, *Emery University, Oxford, Ga.*

GEROULD, JOHN H., Litt.B. (Dartmouth), A.B., A.M., Ph.D. (Harvard), Associate Professor of Biology, *Dartmouth College, Hanover, N. H.*

GLASER, OTTO CHARLES, A.B., Ph.D. (Johns Hopkins), Junior Professor of Zoölogy, *University of Michigan, Ann Arbor, Mich.*

GOLDFARB, A. J., B.S. (College City of New York), Ph.D. (Columbia), Professor of Biology, College of City of New York, *251 West 112th Street, New York City.*

GOLDSCHMIDT, RICHARD B., Ph.D. (Heidelberg), In charge of the Department of Genetics, Kaiser Wilhelm Institut für Biologie, Daalem bei Berlin, Germany (Present address, *Zoölogical Laboratory, Yale University, New Haven, Conn.*).

GOODALE, HUBERT DANA, Ph.D. (Columbia), Research Biologist, *Massachusetts Agricultural Experiment Station, North Amherst, Mass.*

GOODRICH, HUBERT BAKER, B.S. (Amherst), M.A., Ph.D. (Columbia), Instructor in Zoölogy, *Wesleyan University, Middletown, Conn.*

GRAHAM, JOHN YOUNG, Ph.D. (Munich), Professor of Biology, *University of Alabama, University, Ala.*

GRAVE, BENJAMIN H., B.S. (Earlham), M.S. (Carleton), Ph.D. (Johns Hopkins), Professor of Biology, *Knox College, Galesburg, Ill.*

GRAVE, CASWELL, B.S. (Earlham College), Ph.D. (Johns Hopkins), Associate Professor of Zoölogy, *Johns Hopkins University, Baltimore, Md.*

GREGORY, EMILY RAY, A.B. (Wellesley), A.M. (Pennsylvania), Ph.D. (Chicago), *Sweet Briar College, Sweet Briar, Va.*

GREGORY, LOUISE H., A.B. (Vassar), A.M., Ph.D. (Columbia), Instructor in Zoölogy, *Barnard College, New York City.*

GRIFFIN, LAWRENCE EDMONDS, A.B., Ph.B. (Hamline), Ph.D. (Johns Hopkins), Professor of Zoölogy, *University of Pittsburgh, Pittsburgh, Pa.*

GROSS, ALFRED O., A.B., (Illinois), Ph.D. (Harvard), Assistant Professor of Zoölogy, *Bowdoin College, Brunswick, Maine.*

GUDGER, E. W., B.S., M.S., (Nashville), Ph.D. (Johns Hopkins), Professor of Biology, *State Normal School, Greensboro, N. C.*

GULICK, ADDISON, A.B. (Oberlin), A.M. (Harvard), Ph.D. (Würzburg, Germany), Assistant Professor in Physiology, *University of Missouri, Columbia, Mo.*

GUYER, MICHAEL F., B.S. (Chicago), A.M. (Nebraska), Ph.D. (Chicago). Professor of Zoölogy, *University of Wisconsin, Madison, Wis.*

HALL, MAURICE CROWTHER, S.B., M.A., Ph.D., D.V.M., Parasitologist, *Research Laboratory, Parke, Davis & Co., Detroit, Mich.*

HAMAKER, JOHN IRVIN, A.B. (Kansas), A.B., A.M., Ph.D. (Harvard), Professor of Biology, Randolph-Macon Woman's College, *12 Princeton Street, Lynchburg, Va.*

HARGITT, CHARLES W., Ph.D. (Ohio University), Professor of Zoölogy, *Syracuse University, Syracuse, N. Y.*

HARGITT, GEORGE THOMAS, Ph.B. (Syracuse), A.M. (Nebraska), Ph.D. (Harvard), Associate Professor of Zoölogy, Syracuse University, *909 Walnut Avenue, Syracuse, N. Y.*

HARMON, MARY THERESA, A.B., M.A., Ph.D. (Indiana), Assistant Professor of Zoölogy, *Kansas State Agricultural College, Manhattan, Kan.*

HARPER, EUGENE HOWARD, A.B. (Oberlin), A.M. (Harvard), Ph.D. (Chicago), *Bedford, Va.*

HARRISON, ROSS GRANVILLE, Ph.D. (Johns Hopkins), M.D. (Bonn), Bronson Professor of Comparative Anatomy, Yale University, *142 Huntington Street, New Haven, Conn.*

HART, CHARLES A., Systematic Entomologists, Illinois State Laboratory of Natural History, *University of Illinois, Urbana, Ill.*

HARTMAN, CARL G., B.A., M.A., Ph.D. (Texas), Adj. Prof. of Zoölogy, University of Texas, *1908 University Avenue, Austin, Tex.*

HEATH, HAROLD, A.B. (Ohio Wesleyan), Ph.D. (Pennsylvania), Professor of Invertebrate Zoölogy, Leland Stanford University, *231 Walnut Street, Pacific Grove, Cal.*

HEGNER, ROBERT W., B.S., M.S. (Chicago), Ph.D. (Wisconsin), Assistant Professor of Zoölogy, University of Michigan, *1430 Hill Street, Ann Arbor, Mich.*

HEILBRUNN, L.V., Ph.D. (Chicago), University of Illinois Medical School, *Congress and Honore Streets, Chicago, Ill.*

HENCHMAN, ANNIE P., *Box 34, Jaffrey, N. H.*

HENSHAW, SAMUEL, Life Member, Director of Museum of Comparative Zoölogy, *8 Fayerweather Street, Cambridge, Mass.*

HERRICK, CHARLES JUDSON, Ph.D. (Columbia), Professor of Neurology, Anatomical Laboratory, *University of Chicago, Chicago, Ill.*

HERRICK, FRANCIS HOBART, A.B. (Dartmouth), Ph.D. (Johns Hopkins), Sc.D. (Pittsburgh), Professor of Biology, Western Reserve University, *Adelbert College, Cleveland, Ohio.*

Hilton, William Atwood, B.S., Ph.D. (Cornell), Professor Zoölogy, Pomona College, Claremont, Cal.; Director Laguna Marine Laboratory; Editor Journal of Entomology and Zoölogy, *Claremont, Cal.*

Hoge, Mildred Albro, A.B. (Goucher), A.M., Ph.D. (Columbia), Instructor in Zoölogy, *Indiana University, Bloomington, Ind.*

Hogue, Mary Jane, A.B. (Goucher), Ph.D. (Würzburg), Instructor in Zoölogy, *Wellesley College, Wellesley, Mass.*

Holmes, Samuel J., B.S., M.S. (California), Ph.D. (Chicago), Associate Professor of Zoölogy, *University of California, Berkeley, Cal.*

Hooker, Davenport, B.A., M.A., Ph.D. (Yale), Assistant Professor of Anatomy, Yale University, School of Medicine, *846 Orange Street, New Haven, Conn.*

Houser, Gilbert Logan, B.S., M.S. (Iowa), Ph.D. (Johns Hopkins), Professor of Animal Biology and Director of the Laboratories of Animal Biology, *State University of Iowa, Iowa City, Iowa.*

Howard, Arthur D., B.S. (Amherst), M.S. (Northwestern), Ph.D. (Harvard), Scientific Assistant, United States Bureau of Fisheries, Fairport Biological Laboratory, *United States Biological Laboratory, Fairport, Iowa.*

Huntsman, Archibald Gowanlock, B.A., M.D. (Toronto) Lecturer in Biology, Biology Department, *University of Toronto, Toronto, Canada.*

Hussakof, Louis, B.S. (City College of New York), Ph.D. (Columbia), Curator of Ichthyology, American Museum of Natural History, *77th Street and Central Park West, New York City.*

Huxley, Julian Sorell, B.A. (Oxford), Assistant Professor of Biology, *Rice Institute, Houston, Tex.*

Hyde, Roscoe Raymond, A.B., A.M. (Indiana), Ph.D. (Columbia), Assistant Professor of Zoölogy and Physiology, Indiana State Normal School, *636 Chestnut Street, Terre Haute, Ind.*

Ibsen, Heman Lawritz, B.S., M.S., Ph.D. (Wisconsin), Assistant in Experimental Breeding, *University of Wisconsin, Madison, Wis.*

Isely, Frederick B., B.S. (Fairmount), M.S. (Chicago), Professor of Biology, *Central College, Fayette, Mo.*

Jacobs, Merkel Henry, A.B., Ph.D. (Pennsylvania), Assistant Professor of Zoölogy, *University of Pennsylvania, Philadelphia, Pa.*

Jennings, Herbert S., B.S. (Michigan), A.M., Ph.D. (Harvard), LL.D. (Clark), Henry Walters Professor of Zoölogy and Director of the Zoölogical Laboratory, the *Johns Hopkins University, Baltimore, Md.*

Johannsen, Oskar Augustus, B.S. (Illinois), A.M. (Cornell), Ph.D. (Cornell), Professor of Biology, Cornell University, *College of Agriculture, Ithaca, N. Y.*

Johnston, John B., Ph.D. (Michigan), Professor Comparative Neurology, *University of Minnesota, Minneapolis, Minn.*

Jones, Orren Lloyd, B.S., M.S., Ph.D. (Wisconsin), Associate Professor, Animal Husbandry, *Iowa State College, Ames, Iowa.*

Jordan, Harvey Ernest, AB., AM. (Lehigh), Ph.D. (Princeton), Professor of Histology and Embryology, *University of Virginia, University, Va.*

Juday, Chauncey, A.B. and A.M. (Indiana), Biologist, Wisconsin Geological and Natural History Survey; Lecturer in Zoölogy, *University of Wisconsin, Madison, Wis.*

KAMPMEIER, OTTO F., Ph.D., Instructor in Embryology and Comparative Anatomy, School of Medicine, *University of Pittsburgh, Pittsburgh, Pa.*

KELLICOTT, WM. E., Ph.B. (Ohio State University), Ph.D. (Columbia), Professor of Biology, *Goucher College, Baltimore, Md.*

KEPNER, WILLIAM ALLISON, A.B., A.M. (Franklin and Marshall College, Lancaster, Pa.), Ph.D. (Virginia), Associate Professor of Biology, *University of Virginia, University, Va.*

KINCAID, TREVOR, M.S., Professor of Zoölogy, *University of Washington, Seattle, Wash.*

KING, HELEN DEAN, A.B. (Vassar), A.M., Ph.D. (Bryn Mawr), Assistant Professor of Embryology, The Wistar Institute of Anatomy and Biology, *The Wistar Institute, Thirty-sixth and Woodland Avenue, West Philadelphia, Pa.*

KINGSBURY, BENJAMIN FREEMAN, Ph.D. (Cornell), M.D. (Freiburg), Professor of Histology and Embryology, Cornell University, *2 South Avenue, Ithaca, N. Y.*

KINGSLEY, JOHN STERLING, A.B. (Williams), Sc.D. (Princeton), Professor of Zoölogy, *University of Illinois, Urbana, Ill.*

KIRKHAM, WILLIAM BARRI, B.A., M.A., Ph.D. (Yale), Instructor in Biology, Sheffield Scientific School, Yale University, *103 Everit Street, New Haven, Conn.*

KITE, GEORGE LESTER, M.D. (Virginia), Ph.D. (Chicago), *Hoods, Va.*

KNOWER, HENRY McE., A.B., Ph.D. (Johns Hopkins), Professor of Anatomy, Department of Anatomy, *University of Cincinnati, Cincinnati, Ohio.*

KOFOID, CHARLES ATWOOD, A.B., Sc.D. (Oberlin), M.A. (Harvard), Ph.D. (Harvard), Professor of Zoölogy, University of California, and Assistant Director Scripp's Institution of Biological Research, *Berkeley, Cal.*

KORNHAUSER, SIDNEY I., Ph.D., A.M. (Harvard), A.B., (Pittsburgh), Assistant Professor of Zoölogy, Northwestern University, *718 Clark Street, Evanston, Ill.*

KRECKER, FREDERIC H., A.B., Ph.D. (Princeton), A.M. (Cornell), Assistant Professor of Zoölogy, *Ohio State University, Columbus, Ohio.*

KRIBS, HERBERT GUY, A.B. (Oberlin), Ph.D. (Pennsylvania), B.A. (Union), Assistant in Zoölogy, *University of Pennsylvania, Philadelphia, Pa.*

KUNKEL, BEVERLY WAUGH, Ph.B., Ph.D. (Yale), Professor of Zoölogy, *Lafayette College, Easton, Pa.*

KUNTZ, ALBERT, Ph.D. (State University of Iowa), Associate Professor of Biology and Histology, *St. Louis University School of Medicine, St. Louis, Mo.*

LAMBERT, AVERY E., B.S., Ph.D. (Dartmouth), Burr Professor of Natural History, *Middlebury College, Middlebury, Vt.*

LANDACRE, FRANCIS LEROY, A.B. (Ohio), Ph.D. (Chicago) Professor of Anatomy, *Ohio State University, Columbus, Ohio.*

LANE, HENRY HIGGINS, Ph.B. (De Pauw), A.M. (Indiana), Ph.D. (Princeton), Professor of Zoölogy, *University of Oklahoma, Norman, Okla.*

LA RUE, GEORGE R., B.S. (Doane), A.M. (Nebraska), Ph.D. (Illinois), Assistant Professor of Zoölogy, *University of Michigan, Ann Arbor, Mich.*

LASHLEY, KARL SPENCER, A.B. (West Virginia), M.S. (Pittsburgh), Ph.D. (Johns Hopkins), Johnston Fellow, *Johns Hopkins University, Baltimore, Md.*

LAURENS, HENRY, A.B., A.M. (Charleston), Ph.D. (Harvard), Assistant Professor of Biology, Yale College, Osborn Zoölogical Laboratory, *Yale University, New Haven, Conn.*

LEE, THOMAS G., B.S., M.D. (Pennsylvania), Professor of Comparative Anatomy, *University of Minnesota, Institute of Anatomy, Minneapolis, Minn.*

LEFEVRE, GEORGE, A.B., Ph.D. (Johns Jopkins), Professor of Zoölogy, *University of Missouri, Columbia, Mo.*

LILLIE, FRANK R., B.A. (Toronto), Ph.D. (Chicago), Professor of Embryology and Chairman of the Department of Zoölogy, University of Chicago; Director, Marine Biological Laboratory, Woods Hole, Mass. *University of Chicago, Chicago, Ill.*

LINTON, EDWIN, A.B., S.M. (Washington and Jefferson), Ph.D. (Yale), Professor of Biology, Washington and Jefferson College, *400 East Maiden Street, Washington, Pa.*

LITTLE, C. C., A.B., S.D. (Harvard), Research Fellow, Cancer Commission of Harvard University, *Boston, Mass.*

LOCY, WILLIAM ALBERT, Ph.D. (Chicago), Sc.D. (Hon.) (Michigan), Professor of Zoölogy and Director of the Zoölogical Laboratory, *Northwestern University, Evanston, Ill.*

LONG, JOSEPH A., S.B., A.M., Ph.D. (Harvard), Assistant Professor of Embryology, University of California, *1534 La Loma Avenue, Berkeley, Cal.*

LONGLEY, WILLIAM H., M.A., Ph.D. (Yale), Professor of Botany, *Goucher College, Baltimore, Md.*

LUND, ELMER J., Ph.D. (Johns Hopkins University), Assistant Professor of Zoölogy, *University of Minnesota, Minneapolis, Minn.*

LUTZ, FRANK E., A.B. (Haverford), A.M., Ph.D. (Chicago), Assistant Curator of Invertebrate Zoölogy, American Museum of Natural History, *77th Street and Central Park West, New York City.*

MCCLUNG, C. E., Ph.G., A.B., A.M., Ph.D. (Kansas), Professor of Zoölogy and Director of the Zoölogical Laboratory, *University of Pennsylvania, Philadelphia, Pa.*

MCCLURE, CHARLES F. W., A.B., M.A. (Princeton) D.Sc. (Columbia), Professor of Comparative Anatomy, *Princeton University, Princeton, N. J.*

MACCURDY, HANSFORD M., A.B. (Ohio Wesleyan), A.M., Ph.D. (Harvard), Professor of Biology, Alma College, *701 Center Street, Alma, Mich.*

MACDOWELL, EDWIN CARLETON, A.B. (Swarthmore), S.M. Zoöl. (Harvard), S.D. (Harvard), Research Investigator, Station Experimental Evolution, Carnegie Institution of Washington, *Cold Spring Harbor, Long Island, N. Y.*

MACGILLIVRAY, ALEXANDER DYER, Ph.D. (Cornell), Associate Professor Systematic Entomology, University of Illinois, *603 West Michigan Avenue, Urbana, Ill.*

MCGREGOR, JAMES HOWARD, B.S. (Ohio State University), A.M., Ph.D. (Columbia), Associate Professor of Zoölogy, *Columbia University, New York City.*

MCINDOO, NORMAN EUGENE, A.B., A.M. (Indiana), Ph.D. (Pennsylvania), Research Student on Senses of Honey Bee, *Bureau of Entomology, Washington, D. C.*

MALL, FRANKLIN PAYNE, M.A., M.D., Sc.D. (Michigan), LL.D. (Wisconsin), Professor of Anatomy, *Johns Hopkins University, Baltimore, Md.*

MARCHAND, GRACE B., *28 Mercer Street, Princeton, N. J.*

MARK, EDWARD L., A.B. (Michigan), Ph.D. (Leipzig), LL.D. (Michigan), LL.D. (Wisconsin), Hersey Professor of Anatomy and Director of the Zoölogical Laboratory, Harvard University, *109 Irving Street, Cambridge, Mass.*

MARSHALL, RUTH, B.S., M.S. (Wisconsin), Ph.D. (Nebraska), *Lane Technical School, Chicago, Ill.*

MARSHALL, WILLIAM STANLEY, B.S. (Swarthmore), Ph.D. (Leipzig), Associate Professor Entomology, University of Wisconsin, *139 East Gilman Street, Madison, Wis.*

MAST, SAMUEL OTTMAR, B.S. (Michigan), Ph.D. (Harvard), M.Pd. (Michigan Normal College), Associate Professor of Zoölogy, the *Johns Hopkins University, Baltimore, Md.*

MAYER, ALFRED GOLDSBOROUGH, M.E. (Stevens Inst. Tech.), Sc.D. (Harvard), Life Member, Director Department Marine Biology, Carnegie Institution of Washington, Lecturer in Biology, Princeton University, *276 Nassau Street, Princeton, N. J.*

MEAD, ALBERT DAVIS, A.B. (Middlebury), A.M. (Brown), Ph.D. (Chicago), Sc.D. (Pittsburgh), Professor of Biology, Brown University, *283 Wayland Avenue, Providence, R. I.*

METCALF, MAYNARD MAYO, A.B., D.Sc. (Oberlin), Ph.D. (Johns Hopkins), *Oberlin, Ohio.*

METZ, CHARLES W., B.A., Ph.D., Station for Experimental Evolution, *Carnegie Institution of Washington, Cold Spring Harbor, Long Island, N. Y.*

MEYER, ARTHUR WILLIAM, B.S. (Wisconsin), M.D. (Johns Hopkins), Professor of Human Anatomy, Stanford University, *121 Waverley Street, Palo Alto, California.*

MIDDLETON, AUSTIN RALPH, A.B., Ph.D. (Johns Hopkins), Assistant Professor of Biology, *University of Lousiville, Louisville, Ky.*

MOENKHAUS, WILLIAM J., A.B. (Indiana), Ph.D. (Chicago), Professor of Physiology, Indiana University, *501 Fess Avenue, Bloomington, Ind.*

MOODIE, ROY LEE, A.B. (Kansas), Ph.D. (Chicago), Instructor in Anatomy, University of Illinois, Chicago, *Congress and Honore Streets, Chicago, Ill.*

MOODY, JULIA ELEANOR, B.S., M.A. (Mt. Holyoke), Ph.D. (Columbia), Instructor in Zoölogy, *Wellesley College, Wellesley, Mass.*

MOORE, J. PERCY, Ph.D. (Pennsylvania), Life Member, Professor of Zoölogy, *University of Pennsylvania, Philadelphia, Pa.*

MORGAN, ANN HAVEN, A.B., Ph.D. (Cornell), Associate Professor of Zoölogy, *Mt. Holyoke College, So. Hadley, Mass.*

MORGAN, THOMAS HUNT, B.S. (Kentucky), Ph.D. (Johns Hopkins), Professor of Experimental Zoölogy, *Columbia University, New York City.*

MORGULIS, SERGIUS, A.M. (Columbia), Ph.D. (Harvard), *Creighton University Medical School, Omaha, Neb.*

MORRILL, ALBRO DAVID, B.S., M.S. (Dartmouth), Professor of Biology, *Hamilton College, Clinton, Oneida County, N. Y.*

MORRILL, CHARLES V., A.M., Ph.D. (Columbia), Instructor in Anatomy, Cornell University Medical College, *28th Street and First Avenue, New York City.*

MOSHER, EDNA, B.S. (Cornell), Ph.D. (Illinois), Instructor in Entomology, *University of Illinois, Natural History Building, Urbana, Ill.*

MULLENIX, ROLLIN CLARKE, A.B., A.M. (Wheaton), Ph.D. (Harvard), Professor of Biology, Lawrence College, *461 Washington Street, Appleton, Wis.*

MULLER, HERMAN J., A.M., Ph.D., Instructor in Zoölogy, *Rice Institute, Houston, Texas.*

NABOURS, ROBERT K., Ph.D. (Chicago), Professor of Zoölogy, *Kansas Agricultural College, Manhattan, Kan.*

NACHTRIEB, HENRY FRANCIS, B.S. (Minnesota), Professor of Animal Biology and Head of the Department, Curator of the Zoölogical Museum, *University of Minnesota, Minneapolis, Minn.*

NEAL, HERBERT VINCENT, A.B., A.M., Ph.D. (Harvard), Professor of Zoölogy, Tufts College, *Tufts College, Mass.*

NELSON, JAMES ALLEN, Ph.B. (Kenyon College), Ph.D. (Pennsylvania), Expert Bee Culture Investigations, *Bureau of Entomology,* United States Department of Agriculture, *Washington, D. C.*

NEWMAN, HORATIO HACKETT, B.A. (McMaster), Ph.D. (Chicago), Associate Professor of Zoölogy, and Dean in College of Science, University of Chicago, *5712 Dorchester Avenue, Chicago, Ill.*

NORRIS, HARRY WALDO, A.B., A.M. (Grinnell), Professor of Zoölogy, *Grinnell College, Grinnell, Iowa.*

NUTTING, CHARLES CLEVELAND, M.A. (Blackburn), Professor and Head of Department of Zoölogy and Curator of Museum, State University of Iowa, *922 Washington Street, Iowa City, Iowa.*

OSBORN, HENRY FAIRFIELD, A.B., Sc.D. (Princeton), LL.D. (Hon.) (Trinity, Princeton, Columbia), D.Sc. (Hon.) (Cambridge University), Ph.D. (Hon.) (University of Christiania, Upsala), Research Professor of Zoölogy, Columbia; President Board of Trustees, American Museum Natural History; Curator Emeritus Dept. Vertebrate Paleontology, Vertebrate Paleontologist, United States Geological Survey. American Museum of Natural History, *Seventy-seventh Street and Park West, New York City.*

OSBORN, HENRY LESLIE, A.B. (Wesleyan), Ph.D. (Johns Hopkins), Professor of Biology, Hamline University, *1500 Hewitt Avenue, St. Paul, Minn.*

OSBORN, HERBERT, B.Sc., M.Sc. (Iowa State College), Professor of Zoölogy and Entomology, Ohio State University, Director Lake Laboratory, Director Ohio Biological Survey, *Columbus, Ohio.*

OSBURN, RAYMOND C., B.Sc., M.Sc., (Ohio State University), Ph.D. (Columbia), Professor of Biology, *Connecticut College for Women, New London, Conn.*

PACKARD, CHARLES, M.S., Ph.D., Instructor in Zoology, Columbia University, *Schermerhorn Building, Columbia University, New York City.*

PAINTER, THEOPHILUS SHICKEL, A.B. (Roanoke), A.M., Ph.D. (Yale), Adjunct Professor of Zoölogy, *University of Texas, Austin, Texas.*

PARKER, GEORGE HOWARD, S.B., S.D. (Harvard), Professor of Zoölogy, Harvard University, *16 Berkeley Street, Cambridge, Mass.*

PATCH, EDITH M., B.S. (Minnesota), M.S. (Maine), Ph.D. (Cornell), Entomologist, *Maine Agricultural Experiment Station, Orono, Maine.*

PATTEN, BRADLEY MERRILL, A.B. (Dartmouth), A.M., Ph.D. (Harvard), Instructor in Histology and Embryology Western Reserve Medical School, *1353 East Ninth Street, Cleveland, Ohio.*

PATTEN, WILLIAM, B.S. (Harvard), M.A., Ph.D. (Leipzig), Professor of Zoölogy, *Dartmouth College, Hanover, N. H.*

PATTERSON, JOHN THOMAS, B.S. (Wooster), Ph.D. (Chicago), Professor of Zoölogy, University of Texas, *University Station, Austin, Texas.*

PAYNE, FERNANDUS, A.B., A.M. (Indiana), Ph.D. (Columbia), Associate Professor of Zoölogy, *Indiana University, Bloomington, Ind.*

PEARL, RAYMOND, A.B (Dartmouth), Ph.D. (Michigan), Biologist and Head of Department of Biology, *Maine Agricultural Experiment Station, Orono, Maine.*

PEARSE, ARTHUR SPERRY, B.S., A.M. (Nebraska), Ph.D. (Harvard), Associate Professor of Zoölogy, *University of Wisconsin, Madison, Wis.*

PEEBLES, FLORENCE, A.B. (Goucher), Ph.D. (Bryn Mawr), *Newcomb College, New Orleans, La.*

PERKINS, HENRY F., A.B. (Vermont), Ph.D. (Johns Hopkins), Professor of Zoölogy, University of Vermont, *205 South Prospect Street, Burlington, Vt.*

PETRUNKEVITCH, ALEXANDER, Ph.D. (Freiburg), Assistant Professor of Zoölogy, Sheffield Scientific School, Zoölogical Laboratory, *Yale University, New Haven, Conn.*

PHILLIPS, EVERETT FRANKLIN, A.B. (Allegheny), Ph.D. (Pennsylvania), In charge of Bee Culture Investigations, Bureau of Entomology, *United States Department of Agriculture, Washington, D. C.*

PIERSOL, GEORGE ARTHUR, M.S. (Pennsylvania), Sc.D. (Pennsylvaina College), Professor of Anatomy, University of Pennsylvania, *4724 Chester Avenue, Philadelphia, Pa.*

PIKE, FRANK H., A.B. (Indiana), Ph.D. (Chicago), Assistant Professor of Physiology, Columbia University, *437 West 59th Street, New York City.*

PRATT, HENRY SHERRING, A.B. (Michigan), A.M., Ph.D. (Leipzig), Professor of Biology, *Haverford College, Haverford, Pa.*

RAND, HERBERT WILBUR, A.B. (Allegheny, Harvard), A.M., Ph.D. (Harvard), Assistant Professor of Zoölogy, Harvard University; *Museum of Comparative Zoölogy, Cambridge, Mass.*

RANDOLPH, HARRIET, A.B. (Bryn Mawr), Ph.D. (Zurich), Life Member, *1310 South Forty-seventh Street, Philadelphia, Pa.*

RANSOM, BRAYTON HOWARD, B.Sc., M.A., Ph.D. (Nebraska), Chief, Zoölogical Division, Bureau of Animal Industry, United States Department of Agriculture, *Bureau of Animal Industry, Washington, D. C.*

REED, HUGH DANIEL, B.S., Ph.D. (Cornell), Assistant Professor of Zoölogy, Cornell, *108 Brandon Place, Ithaca, N. Y.*

REESE, ALBERT MOORE, A.B., Ph.D. (Johns Hopkins), Professor of Zoölogy, *West Virginia University, Morgantown, W. Va.*

REIGHARD, JACOB ELLSWORTH, Ph.B. (Michigan), Professor of Zoölogy; Director of Zoölogical Laboratory and Biological Station, *University of Michigan, Ann Arbor, Mich.*

REINKE, EDWIN EUSTACE, M.A. (Lehigh), Ph.D. (Princeton), Assistant Professor of Biology, *Vanderbilt University, Nashville, Tenn.*

Rice, Edward Loranus, A.B. (Wesleyan), Ph.D. (Munich), Professor of Zoölogy, *Ohio Wesleyan University, Delaware, Ohio.*

Richards, A., B.A. (Kansas), M.A. (Wisconsin), Ph.D. (Princeton), *Wabash College, Crawfordsville, Ind.*

Riddle, Oscar, A.B. (Indiana), Ph.D. (Chicago), Research Associate, Carnegie Institution of Washington, *Cold Spring Harbor, Long Island, N. Y.*

Riley, William Albert, B.S. (DePauw), Ph.D. (Cornell), Professor of Insect Morphology and Parasitology, *Cornell University, Ithaca, N. Y.*

Ritter, William E., A.B. (California), A.M., Ph.D. (Harvard), Director of Scripps Institution for Biological Research of the University of California, Professor of Zoölogy, *University of California, La Jolla, Cal.*

Robertson, Alice, B.S., M.S., Ph.D. (California), Professor of Zoölogy, *Wellesley College, Wellesley, Mass.*

Robertson, William R. B., A.B. (Kansas), Ph.D. (Harvard), Assistant Professor of Zoölogy, University of Kansas, *1420 Ohio Street, Lawrence, Kans.*

Rogers, Charles Gardner, A.B., A.M. (Syracuse), Ph.D. (California), Professor of Comparative Physiology, *Oberlin College, Oberlin, Ohio.*

Rogers, Fred Terry, A.B., Ph.D. (Chicago), Assistant Professor of Zoölogy, *Baylor University, Waco, Texas.*

Ruthven, Alexander G., B.S. (Morningside), Ph.D. (Michigan), Director, Museum of Zoölogy, Assistant Professor of Zoölogy, University of Michigan, *Museum of Zoölogy, Ann Arbor, Mich.*

Schaeffer, Asa Arthur, A.B. (Franklin and Marshall), Ph.D., (Johns Hopkins) Associate Professor of Zoölogy, *University of Tennessee, Knoxville, Tenn.*

Schiedt, Richard C. F., Ph.D. (Pennsylvania), Sc.D. (Hon.) (Franklin and Marshall), Professor of Biology and Geology, Franklin and Marshall College, *1043 Wheatland Avenue, Lancaster, Pa.*

Scott, George G., A.B., A.M. (Williams), Ph.D. (Columbia), Assistant Professor, Natural History, *College of the City of New York, New York City.*

Scott, John W., A.B., A.M. (Missouri), Ph.D. (Chicago), Professor of Zoölogy, *University of Wyoming, Laramie, Wy.*

Scott, William, Ph.D. (Indiana), Assistant Professor of Zoölogy, *Indiana University, Bloomington, Ind.*

Sheldon, Ralph Edward, A.B., A.M. (Cornell), S.M. (Harvard), Ph.D. (Chicago), Assistant Professor of Anatomy and Director of Anatomical Laboratories, *University of Pittsburgh, School of Medicine, Pittsburgh, Pa.*

Shelford, Victor Ernest, B.S., Ph.D. (Chicago), Assistant Professor of Zoölogy, University of Illinois, and Biologist of Illinois State Laboratory, *506 West Iowa Street, Urbana, Ill.*

Shepherd, W. T., A.M., Ph.D., Professor of Zoölogy and Dean, *Waynesburg College, Waynesburg, Pa.*

Shorey, Marian Lydia, A.M. Ph.B., (Brown), Ph.D. (Chicago), *Hugenot College, Wellington, South Africa.*

Shull, Aaron Franklin, A.B. (Michigan), Ph.D. (Columbia), Associate Professor of Zoölogy, University of Michigan, *520 Linden Street, Ann Arbor, Mich.*

Sigerfoos, Charles P., B.S. (Ohio State), Ph.D. (Johns Hopkins), Professor of Zoölogy, *University of Minnesota, Minneapolis, Minn.*

SMALLWOOD, WILLIAM MARTIN, Ph.D. (Harvard), Professor of Comparative Anatomy, Syracuse University, *525 Euclid Avenue, Syracuse, N. Y.*

SMITH, BERTRAM GARNER, A.B. (Michigan), Ph.D. (Columbia), Assistant Professor of Zoölogy, Michigan State Normal College, *122 College Place, Ypsilanti, Mich.*

SMITH, FRANK, Ph.B. (Hillsdale College), A.M. (Harvard), Professor of Zoölogy, *University of Illinois, Urbana, Ill.*

SMITH, LUCY WRIGHT, B.A. (Mt. Holyoke), M.A., Ph.D. (Cornell), Instructor in Zoölogy, *Mt. Holyoke College, South Hadley, Mass.*

SMITH, SIDNEY I., Ph.B., A.M. (Yale), Professor of Comparative Anatomy, Emeritus, *Yale University, New Haven, Conn.*

SPAETH, REYNOLD A., Ph.D. (Harvard), Instructor in Biology, Yale University, *Osborn Zoological Laboratory New Haven, Conn.*

STILES, CHARLES W., A.M., Ph.D. (Leipzig), S.M., S.D. (Wesleyan), Life Member, Professor of Zoölogy, United States Public Health and Marine Hospital Service, Hygienic Laboratory. *Twenty-fifth and E Streets, N. W., Washington, D. C.* (October 1–May 1); *Wilmington, N. C.* (May–October 1).

STOCKARD, CHARLES RUPERT, B.S., M.S. (Mississippi Agricultural and Mechanical College), Ph.D. (Columbia), Professor of Anatomy, Cornell University, Medical School, Cornell Medical College, *First Avenue and Twenty-eighth Street, New York City.*

STROMSTEN, FRANK ALBERT, B.S., M.S. (Iowa), D.Sc. (Princeton), Assistant Professor of Animal Biology, State University of Iowa, *943 Iowa Avenue, Iowa City, Iowa.*

STRONG, OLIVER S., A.B., A.M. (Princeton), Ph.D. (Columbia), Instructor in Anatomy, Columbia University, College of Physicians and Surgeons, *437 West Fifty-ninth Street, New York City.*

STRONG, REUBEN MYRON, A.B. (Oberlin), A.M., Ph.D. (Harvard), *Vanderbilt University Medical School, Nashville, Tenn.*

STURTEVANT, ALFRED H., A.B., Ph.D. (Columbia), Cutting Fellow, *Columbia University, New York City.*

SUMNER, FRANCIS B., B.S. (Minnesota), Ph.D. (Columbia), Biologist, *Scripps Institution for Biological Research, La Jolla, Cal.*

SURFACE, FRANK M., A.B., A.M. (Ohio State), Ph.D. (Pennsylvania), Biologist, *Maine Experiment Station, Orono, Maine.*

SWEZY, OLIVE, B.S., M.S., Ph.D., (California), Associate in Zoölogy, Assistant Zoölogist, Scripps Institution for Biological Research, University of California, *East Hall, University of California, Berkeley, Cal.*

TANNREUTHER, GEORGE W., A.B. (Manchester), A.M. (Antioch), Ph.D. (Chicago), Instructor in Zoölogy, *University of Missouri, Columbia, Mo*

TASHIRO, SHIRO, B.S., Ph.D. (Chicago), Instructor in Physiological Chemistry, University of Chicago, *Hull Bro. Chemical Laboratory, Chicago, Ill.*

TENNENT, DAVID HILT, B.S. (Olivet), Ph.D. (Johns Hopkins), Professor of Biology, *Bryn Mawr College, Bryn Mawr, Pa.*

THOMPSON, CAROLINE BURLING, S.B., Ph.D. (Pennsylvania), Associate Professor of Zoölogy, Wellesley College, *Leighton Road, Wellesley, Mass.*

TORREY, HARRY BEAL, B.S., M.S. (California), Ph.D. (Columbia), Professor of Biology, *Reed College, Portland, Ore.*

TOWER, WILLIAM LAWRENCE, S.B. (Chicago), Assistant Professor of Zoölogy, *University of Chicago, Chicago, Ill.*

TREADWELL, AARON L., B.S., M.S. (Wesleyan), Ph.D. (Chicago), Professor of Biology, *Vassar College, Poughkeepsie, N. Y.*

TYLER, JOHN MASON, Ph.D. (Hon.) (Colgate), Professor of Biology, *Amherst College, Amherst, Mass.*

VAN CLEAVE, HARLEY JONES, B.S. (Knox College), M.S., Ph.D. (Illinois), Associate in Zoology, *300 Natural History Building, Urbana, Ill.*

VERRILL, ADDISON E., S.B. (Harvard), A.M. (Yale), Professor of Zoölogy, Emeritus, *Yale University, New Haven, Conn.*

WAGNER, GEORGE, M.A. (Michigan), Assistant Professor of Zoölogy, *University of Wisconsin, Biology Building, Madison, Wis.*

WAITE, FREDERICK CLAYTON, Litt.B. (Adelbert), A.M. (Western Reserve), A.M., Ph.D. (Harvard), Professor of Histology and Embryology, School of Medicine, Western Reserve University, *1353 East 9th Street, Cleveland, Ohio.*

WALLACE, LOUISE BAIRD, A.B. (Mount Holyoke), Ph.D. (Pennsylvania), Dean of Constantinople College, Constantinople, Turkey, *South Hadley, Mass.*

WALTER, HERBERT EUGENE, A.B. (Bates), A.M. (Brown), Ph.D. (Harvard), Assistant Professor of Biology, *Brown University, Providence, R. I.*

WALTON, LEE BARKER, Ph.B. (Cornell), A.M. (Brown), Ph.D. (Cornell), Professor of Biology, *Kenyon College, Gambier, Ohio.*

WARD, HENRY BALDWIN, A.B. (Williams), A.M., Ph.D. (Harvard), Professor of Zoölogy, *University of Illinois, Urbana, Ill.*

WELCH, PAUL SMITH, A.B. (James Millikin), A.M., Ph.D. (Illinois), Assistant Professor of Entomology, *Kansas State Agricultural College, Manhattan, Kan.*

WELLS, MORRIS MILLER, B.S. (Chicago), Ph.D. (Illinois), Instructor Department of Zoölogy, *University of Chicago, Chicago, Ill.*

WENRICH, DAVID HENRY, B.A., M.A., Ph.D., Instructor in Zöology, *University of Pennsylvania, Zoological Laboratory, Philadelphia, Pa.*

WENTWORTH, EDWARD N., M.S. (Iowa), Professor of Animal Husbandry, *Kansas State Agricultural College, Manhattan, Kans.*

WERBER, ERNEST I., Ph.D. (Vienna), Sessel Research Fellow, *Yale University, Osborn Zoölogical Laboratory, New Haven, Conn.*

WHEELER, WILLIAM MORTON, Ph.D. (Clark), Professor of Economic Entomology, *Bussey Institution, Forest Hills, Boston, Mass.*

WHITING, PHINEAS W., A.B., M.S., Ph.D., Harrison Research Fellow, *University of Pennsylvania, Zoölogical Laboratory, Philadelphia, Pa.*

WHITNEY, DAVID DAY, B.A. (Wesleyan), M.A., Ph.D. (Columbia), Department of Zoölogy, *University of Nebraska, Lincoln, Neb.*

WIEMAN, HARRY LEWIS, A.B., A.M. (Cincinnati), Ph.D. (Chicago), Associate Professor of Zoölogy, Head of Department, *University of Cincinnati, Cincinnati, Ohio.*

WILDER, HARRIS HAWTHORNE, A.B. (Amherst), Ph.D. (Freiburg), Professor of Zoölogy, *Smith College, Northampton, Mass.*

WILDER, INEZ WHIPPLE, Ph.B. (Brown), A.M. (Smith), Instructor in Zoölogy, *Smith College, Northampton, Mass.*

WILDMAN, EDWARD E., B.S., M.S., Ph.D. (Pennsylvania), Head Department of Science, West Philadelphia High School for Girls, *4331 Osage Avenue, Philadelphia, Pa.*

WILLARD, W. A., Ph.B. (Grinnell), A.M. (Tufts and Harvard), Ph.D. (Harvard), Professor of Histology and Embryology in Charge of Department, *University of Nebraska, College of Medicine, Omaha, Neb.*

WILLIAMS, STEPHEN RIGGS, A.B., A.M. (Oberlin), A.M., Ph.D. (Harvard), Professor of Zoölogy and Geology, Miami University, *300 East Church Street, Oxford, Ohio.*

WILSON, CHARLES BRANCH, A.B., A.M. Sc.D. (Colby), Ph.D. (Johns Hopkins), Head Science Department, *State Normal School, Westfield, Mass.*

WILSON, EDMUND B., Ph.B. (Yale), Ph.D. (Johns Hopkins), LL.D. (Yale, Chicago, Hopkins), M.D. (Hon.) (Leipzig), Sc.D. (Cambridge), Da Costa Professor of Zoölogy, *Columbia University, New York City.*

WILSON, HENRY VAN PETERS, A.B., Ph.D. (Johns Hopkins), Professor of Zoölogy, *University of North Carolina, Chapel Hill, N. C.*

WODSEDALEK, JERRY EDWARD, Ph.D., M.Ph., Ph.D. (Wisconsin), Professor of Zoölogy and Head of the Department of Zoölogy and Entomology, *University of Idaho, Moscow, Idaho.*

WOLCOTT, ROBERT HENRY, B.Sc., M.D. (Michigan), M.A. (Nebraska), Professor and Head of the Department of Zoölogy, *University of Nebraska, Lincoln, Neb.*

WOODRUFF, LORANDE LOSS, A.B., A.M., Ph.D. (Columbia), M.A. (Yale), Professor of Biology, *Yale University, Osborn Zoölogical Laboratory, New Haven, Conn.*

WRIGHT, ALBERT HAZEN, A.B., A.M., Ph.D. (Cornell), Assistant Professor of Systemic and Field Zoölogy, Cornell University, *Cayuga Heights, Ithaca, N. Y.*

WRIGHT, SEWALL G., S.B. (Lombard), S.M. (Illinois), S.D. (Harvard), Senior in Animal Breeding Investigation, Animal Husbandry Division, Bureau of Animal Industry, Department of Agriculture, *Washington, D. C.*

YERKES, ROBERT M., Ph.D. (Harvard), Assistant Professor of Comparative Psychology, Harvard University, *Emerson Hall, Cambridge, Mass.*

YOUNG, ROBERT T., B.S. (Pennsylvania), Ph.D. (Nebraska), Professor of Zoölogy, *University of North Dakota, University, N. D.*

ZELENY, CHARLES, B.S., M.S. (Minnesota), Ph.D. (Chicago), Professor of Zoölogy, *University of Illinois, Urbana, Ill.*

EFFICIENCY

The Principles of Scientific Shop Management as Applied to the Printing Business

WE manufacture THE ANATOMICAL RECORD We produce between 40 and 50 scientific and technical publications in addition to a large number of single volumes of transactions and proceedings

¶All are handled on a *definite schedule* maintaining the highest standard of mechanical workmanship

Waverly Press

WILLIAMS & WILKINS COMPANY

2419-2421 GREENMOUNT AVE.

BALTIMORE, MD.

U. S. A.

日本解剖學者及動物學者諸君

謹啓　現下歐洲ニ於ケル不幸ナル戰禍ハ各方面ニ少ナカラヌ影響ヲ及ボシ候ガ就中科學的研究ハ多大ナル阻碍ヲ蒙リ歐洲ニ於ケル解剖學及動物學ニ關スル幾多ノ雜誌ハ或ハ發行中止ノ已ムナキニ至レルモノアリ、然ラザルモノモ之ヲ米國ニ於テ手ニ入ルルコト甚ダ困難ナル狀態ニ有之申候　就テハ

形態學雜誌、比較神經學雜誌、解剖學雜誌、解剖學彙報、實驗動物學雜誌

五雜誌ノ編輯局ハ此時局ニ際シテ及ブ限リ右學術ノ研究ニ對シ補助ト奬勵トヲ與ヘン希望ヲ以テ世界各國研究所ノ業績ニ對シ廣ク出版上ノ便宜ヲ斗ルコトニ相成申候　即チ解剖學及動物學上ノ諸論文ハ其編輯當局ノ認許ヲ得次第迅速ニ英、佛、獨、伊及西班牙語ノ何レニテモ登載可仕候　從來上記ノ五雜誌ハ生物學ニ關スル米國研究家ノ業績ノ大多數ヲ網羅シ且世界各國ニ最モ廣ク汎布致サルル有力ナル雜誌ニテ孰レモ米國費府ウィスター研究所ガ斯學推輓ノ目的ニテ出版致シ居ルモノニ有之其編輯局ハ米國及加奈太ノ重ナル代表的研究家ノ殆ド凡テヲ包含致居候　就テハ今回右編輯局ハ日本帝國ニ於ケル解剖學及動物學者ノ御便宜ノ爲メ其業績ヲ右五雜誌ニ於テ發表セラレンコトヲ切望致候　而テ之ニ依テ將來日米兩國研究者間ノ親交ヲ幇助スルコトヲ得バ至幸實ニ之ニ過ギズト存候　尚出版ニ關スル凡テノ御照會ハ何卒左記ヘ宛テ御文通被成下度願上候　敬具

北米合衆國ペンシルヴェニア州フィラデルフィア市

ウィスター解剖學及生物學研究所　所長　ドクトル　ミルトン、ジェー、グリーンマン

7699 057